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Maya City Planning and the Calendar

ANTHONY AVENI

and

HORST HARTUNG

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The American Philosophical Society dedicates this volume to
the memory of Tatiana Proskouriakoff.

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In our opinion, the best available published map of Uxmal is still the one by Morley ("The Ancient Maya," 1946, revised third edition 1956, plate 49). A re-drawn version with several changes was used by one of the authors in 1971 and this is the one presented here, although our recent measurements at the site show in some parts slightly different orientations of the structures.

The map of Chacmultun should be regarded only as a sketch-map. Marquina's drawing (1951, 740) was taken as a base and our measurements at the site in January 1980 were considered for the orientations of the principal buildings.

INTRODUCTION: THE ORIENTATION PROBLEM AND CATEGORIES OF EXPLANATION

This study focuses on the question: Why do people orient buildings the way they do? That the depiction of the cardinal directions of space had something to do with events taking place in the sky is immediately suggested by cosmological diagrams derived from the civilizations of ancient Mexico (fig. 1). The first (a), drawn in Central Mexico before the Conquest, is a rather complex picture in which a centrally located creator god, from whom life-giving streams of blood flow, appears surrounded by the qualities associated with each of the directions; thus, the trees, birds, gods, colors, the names of the days of the week symbolizing those directionally based qualities are framed within one of the four appropriate branches of a Maltese cross. The count of the 260-day sacred calendar proceeds, dot by dot, around the border of the diagram. In the middle of the top flap of the cross, which represents the direction east, the place where the sun is born, is the disc of the rising sun perched on an altar at the base of the eastern tree. On the other side, a skull or death head symbolizes the west, the place where the sun dies. Note that the east and west segments of the cross, unlike the other opposing pair, which may represent north-south or possibly up-down, are attached to the center frame of the diagram as if to assign this axial direction greater importance.

The Maya version of this diagram (fig. 1b) bears a striking resemblance to its counterpart from Central Mexico, even down to the count of 260 dots around the horizon. We find one of the gods at the top (east) sector of a more hastily drawn cross holding the glyphic symbol of the sun, "kin," a word which translates from most Maya languages as sun, day, and time. A diagram from Post-Conquest Yucatan, intended perhaps more as a calendrical counting device than a depiction of Maya cosmology or world view, again has east at the top of the diagram and like the west (below), the direction contains the word sun in its name (fig. 1c). In an even more hispanicized version of the calendar (fig. 1d) we see the fifty-two Aztec New Year's Day names, each divided among the four directions. This time, Spanish gloss replaces the directional names ordinarily assigned in the native language but east is still at the top of the diagram, now bearing a designation more familiar to us: "oriente."

Orientation, as the root word suggests, originally meant the angular deviation in direction from true east, a place chosen perhaps because it represented the central position of sunrises over the course of the year. In many cultures one finds that an orientation calendar, a scheme for counting

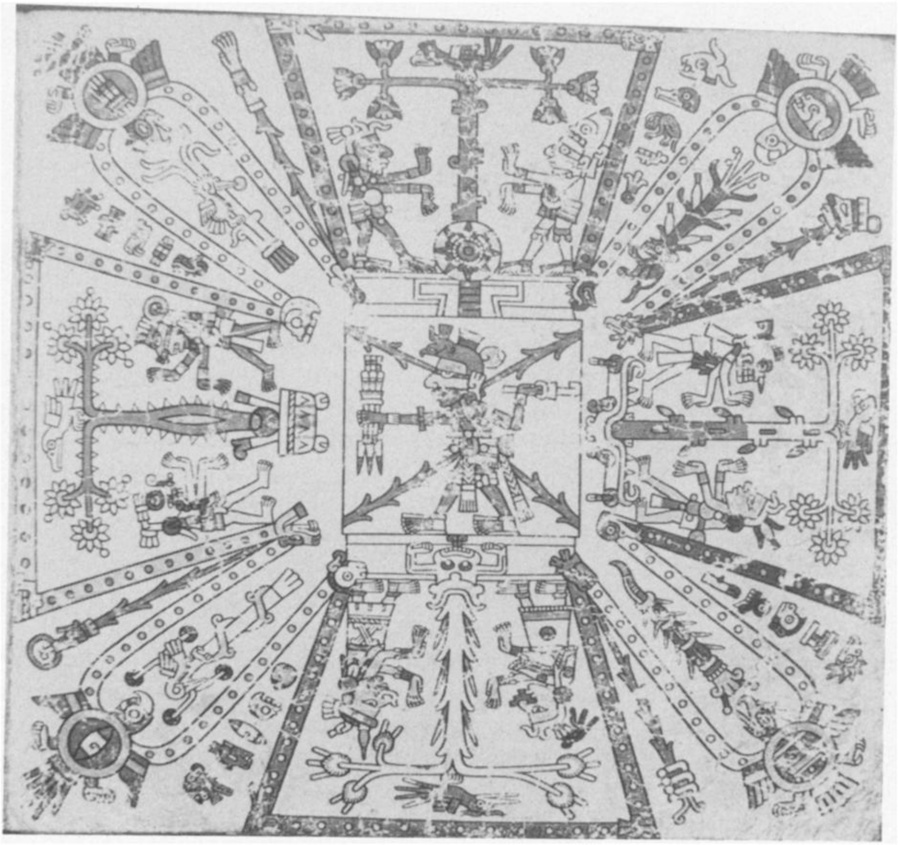

FIG. 1. Diagrams representing cosmology, world view, and calendar among the civilizations of ancient Mexico.

FIG. 1a. World view diagram from Codex Fejervary Mayer, p. 1 (*Codices Selecti* vol. XXVI, Graz: Akad. Druck-u Verlag).

the days derived by following the annual course of the sun on the horizon, is deeply rooted in a tradition of deliberately laying out alignments to various points in the landscape. When we speak of an alignment, we refer to the direction, measured clockwise (looking down on a site map) from true (astronomical) north of the facade of the building, a line between two buildings, etc. But when we use the term orientation, we imply that the alignment was intended deliberately to connect one point in the architecture to another, or to a point specifically chosen on the horizon. Simply stated, an orientation is an alignment with a purpose.

Dinsmoor (1939), Fuson (1969), Wheatley (1971), and Carlson (1982) are among those who have summarized the factors that might determine building orientations in various cultural contexts. These include:

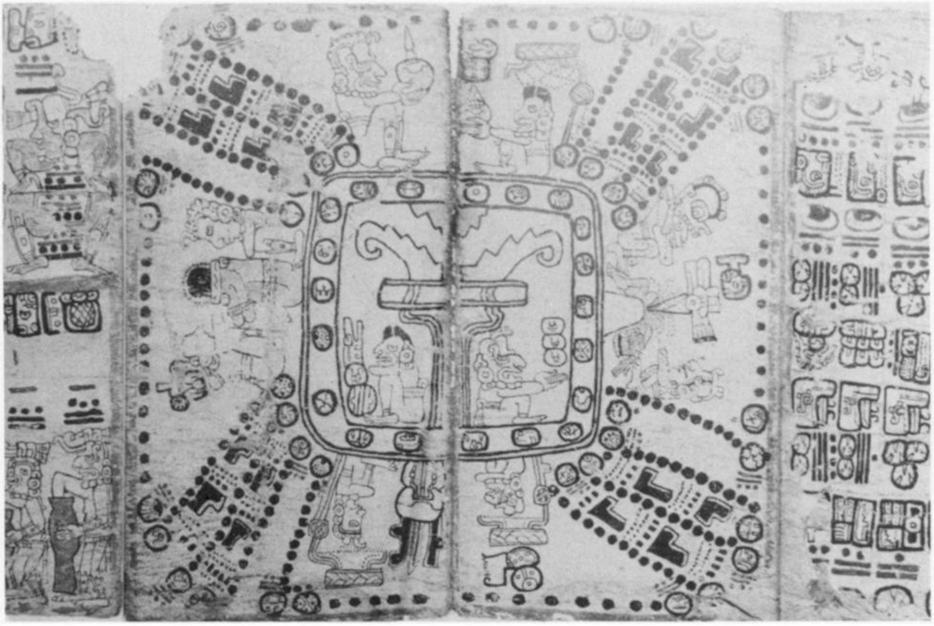

FIG. 1b. World view diagram from Codex Madrid, p. 75–76 (*Codices Selecti* vol. VIII, Graz: Akad. Druck-u Verlag).

(1) *Topography or Geomorphology* (the relation to the landscape, streets, or other buildings)

Building alignments might be dictated by the shape of the hill or valley upon which a structure is built, or by the course of a river adjacent to a building site, or of the neighboring coastline. Alignments of most of the buildings of many modern cities fall under this category, often because they were placed and oriented according to a city plan ordained long in the past.

(2) *Climate* (the direction of prevailing winds, maximizing seasonal light and warmth, ventilation, health considerations, etc.)

Meteorological conditions might be expected to be more influential in placing housing units as opposed to civic or ceremonial centers. This factor was paramount in the layout of Mayapan (Carlson 1982) and in the orientation of Atoni households in Timor (Cunningham 1973).

(3) *Religion* (locations and/or directions prescribed by cult or tradition)

The location of the Pyramid of the Sun at Teotihuacan over a cave (Heyden 1975) or of the Parthenon on a lofty hilltop are examples (Scully 1962, 171–72). On a smaller scale, the position of Neolithic burials with the feet to the east also may be cited in this category (Sommerville 1928,

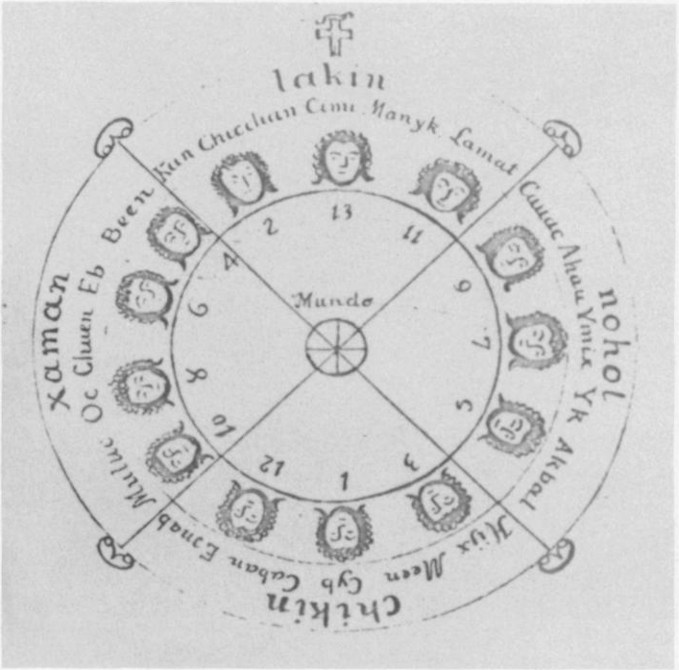

FIG. 1c. Calendar diagram from the Book of Chilam Balam of Kaua (After N. Bowditch, 1910, The *Numeration, Calendar Systems, & Astronomical Knowledge of the Mayas,* Cambridge: Cambridge University Press).

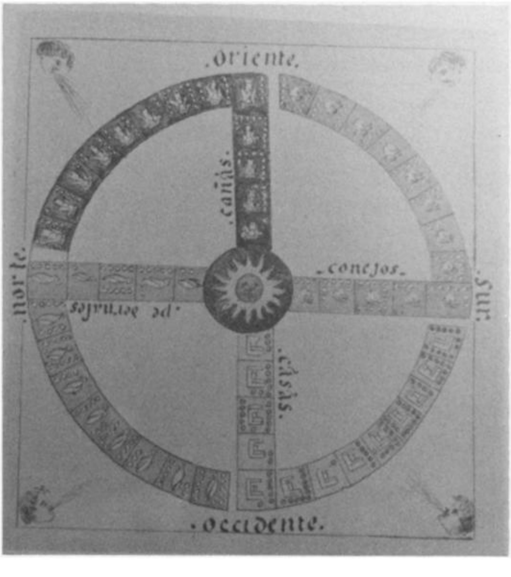

FIG. 1d. Calendar diagram from chronicle of D. Duran (1971, *The Book of the Gods and Rites and the Ancient Calendar.* Trans and Ed. F. Horcasitas & D. Heyden, Norman: University of Oklahoma Press, 35).

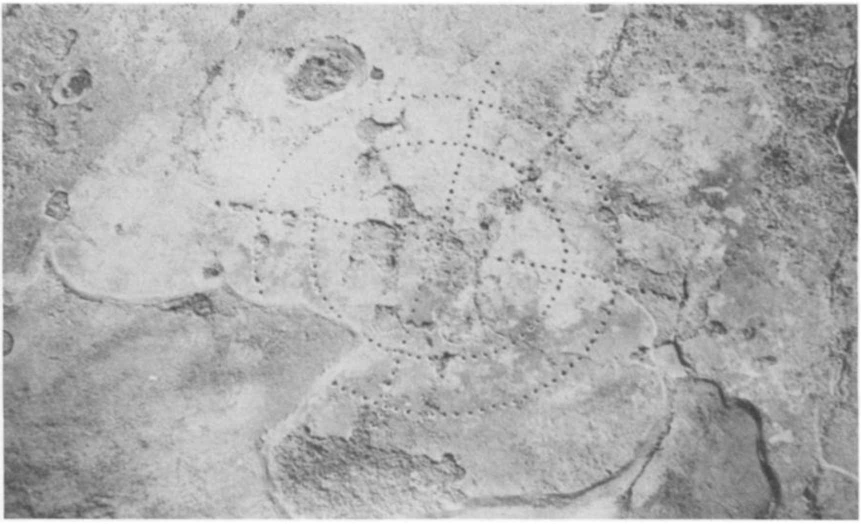

FIG. 1e. Pecked Circle (TEO-17) in the Ciudadela of Teotihuacan.

37). Christian churches in medieval times were usually oriented with their main altar facing toward the east while Muslim mosques were aligned to point quite precisely toward Mecca (King 1982).

(4) *Astronomy*

The debate over the extent to which astronomical events played a role in the orientation of the ancient buildings of various cultures has been

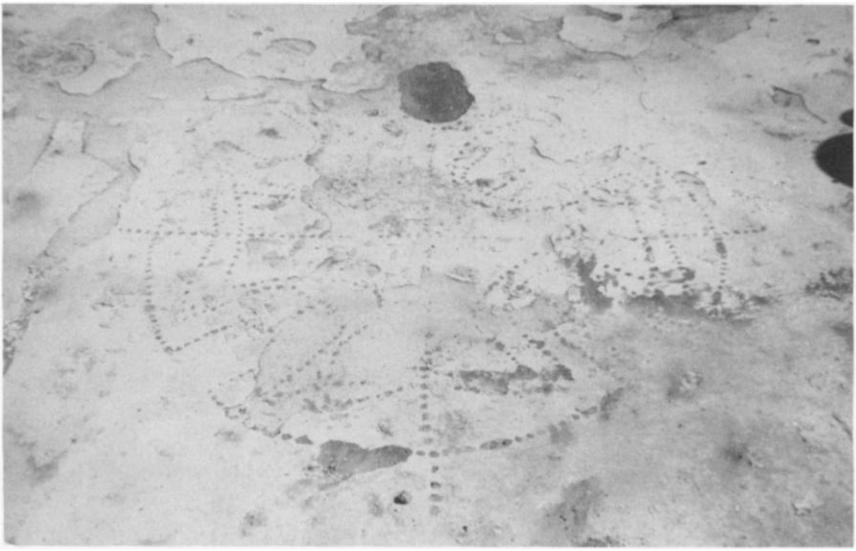

FIG. 1f. Pecked Circle (TEO-2) in structure adjacent to Street of the Dead at Teotihuacan.

widespread. Explanations range from a blind devotion to astronomy as precise knowledge for its own sake, which seems to be the hypothesis advocated by the Thoms (1967) for many of the alignments of British Megalithic sites, to, on the other hand, astronomy for practical purposes such as the establishment of a general civic or agricultural orientation calendar.

(5) *Magnetism and "Geomancy"*

An unusual motive for orientation in most cultures, but one which evidently played a profound role in the ancient Chinese city (Wheatley 1971), terrestrial magnetism is combined with several other factors into a rather nebulous category Carlson calls geomantic: "an occult divinatory process that fixed the location and orientation of all human constructs." It consisted of "a constellation of physical, cultural, and often mystical elements used to place man and his residences—in harmony with the 'cosmic forces' " (Carlson 1982, 52). While it has been pointed out that many Maya buildings align with the present magnetic declination in Yucatan (6°–8° E/N) (Fuson 1969; Sartor 1974), it also has been argued that any causal relationship is likely fortuitous (Aveni 1975; Carlson 1982).

(6) *Social Considerations*

Factors relating to politics, economics, or technological considerations such as the positioning of defensive structures, the establishment of trade routes, etc. often serve to determine how a building is laid out.

(7) *Chance or Randomness*

Because modern cities tend to be built over the sites of earlier settlements, often preserving the original alignments for convenience, one can lose sight of the ecological considerations of one's ancestors; i.e., the factors that lay behind the original establishment of a city plan may be totally irrelevant in the present context. For example, Siemens (1983) and Tichy (1974), respectively, have discovered that the alignment of planted fields and churches in certain regions of Mexico simply follow the directions of alignments established in pre-Columbian times. Dinsmoor (1939, 96) tells us that the older buildings of the British School in Athens were located on the site of a tennis court that offered a ready-made excavation for the foundation.

As we can see from the foregoing list, it is difficult to separate the factors that might have been taken into consideration in orienting a particular building. For example, the religious beliefs that dictated where to locate the Athenian Parthenon may have depended upon the topography. The use of the tennis court for the site of the British School (under no. 7) also may be considered an economic convenience (no. 6) or perhaps it was dictated by a pre-ordained plan (no. 1). Those who study astronomical orientations in ancient cultures know that quite often astronomy and religion go together. Moreover, when we try to relate astronomical orientations to the determination of dates in the agricultural year, we must consider climatological or meteorological factors. Finally, the geomantical category of explanation provides a catch-all for a large number of interrelated factors. Hence, both the reader and the investigator need to be cautioned about pushing the foregoing taxonomy of orientation factors too far. Nevertheless, the list at least serves to keep us aware of the multitude of possible causes for any building alignment.

Here we are concerned with the analysis of a large corpus of data on the alignment of ceremonial and civic buildings of ancient Mesoamerica, particularly those of the Maya region. Our goal is to determine the extent to which these buildings were oriented astronomically. We also examine possible motives for the orientation of certain specific buildings. Most of these data have been collected at sites using a theodolite (surveyor's transit). Most of the alignments have been measured relative to astronomical north utilizing a method developed and elaborated by Aveni (1980, 128–32). Such data are far more precise (error ± 10 minutes of arc) than those acquired from archaeological site maps or read on-site with the magnetic compass (Aveni 1975, 163). Where possible, the alignments are derived from original rather than from reconstructed foundations, walls, or doorways. In most cases, it is necessary to apply such techniques in the field in order to equal or slightly exceed the precision exhibited by the builders, lest one employ erroneous data when evaluating orientation hypotheses (Aveni 1981a, 164–65). Unfortunately, the reason for seeking precision of this order in the data-gathering process often has been misunderstood, e.g., some critics have inferred that the tools and methods employed in the investigation are assumed by the investigator to have been a part of the program of the builders (Rowe 1979, 231).

We are especially concerned with the causal factor(s) that might have lain behind the widespread systematic alignments which emerge from a large mass of data. While we devote much attention to astronomical factors in attempting to arrive at causal explanations for these alignments, we attempt to remain mindful of the multitude of orientation factors discussed above, of which astronomy may have been but an integral part. Thus, we try to place astronomy and calendar where it belongs: in the broader context of a set of interrelated reasons for building placement and orientation; this is a consideration all too easily avoided in many discussions of astronomical orientations. As in the discussion of the correlation of the Mesoamerican and Christian calendars, one can be deceived into thinking that a "clean" solution, unencumbered by reference to ethnohistorical documents or other culture-related data, is possible. It is probably this single-explanation approach that prompted Thompson (1974, 94) to admonish investigators "against crediting the Maya with intention and precision for every significant orientation noted."

The astronomical hypothesis would seem especially worthy of consideration if we find alignments that are confined to a narrow azimuthal range in a sample of buildings spread far apart in space. In this case, there can be no conceivable way of actually laying out the chosen direction other than by the use of astronomical bodies at the horizon as reference objects. The employment of such a tactic, however, immediately raises the question of whether the builders chose celestial bodies as a matter of convenience, simply to establish and disseminate architectural rules adopted by the state, or whether such orientations served the practical function of formally marking significant dates in the civic, religious, or agricultural calendar. Regarding the second alternative, it is often pointed out that organized societies had no practical need of precisely determining dates by registering astronomical phenomena in the doorways of buildings or along a line between two stone monuments on the opposite side of a valley adjacent to a ceremonial center. For example, Thompson (1974, 94–95) tells us the modern Maya know when to slash and burn—when the humidity increases. But he completely overlooks one of the most fundamental roles ceremonial architecture played in many ancient cultures: to make manifest in the works of man the cosmic principles of hierarchical order upon which so much religious thought is based.

Like a written text, ceremonial architecture provides us with information about a culture's world view, including a conception of what we call the natural world. Thus, the round shape of the Temple of Quetzalcoatl as Ehecatl, the Central Mexican God of Wind, imitates the circulatory pattern of the winds of the *tormelino* ("dust devil"). Buildings and stelae are often laden with representations of the things of nature. For example, Stela 10 of Seibal offers us a rich zoological and botanical body of data from the Peten rain forest of Guatemala. One can identify several species of plants and animals adorning the ruler who occupies the central position. The symmetry and periodicity inherent in the movement of things in the sky represent one of nature's most well-regulated and easily detectable offerings. Consequently, it is reasonable to seek astronomical directions that might have been incorporated into general site plans such as that of Teotihuacan (Millon et al. 1975). To be particularly scrutinized are potential astronomical orientations in assemblages that are characterized by individual buildings or complexes that possess an unusual shape and/or orientation relative to other structures at a site, e.g., the Caracol of Chichen Itza (Aveni et al. 1975); Group E, Uaxactun (Ricketson 1928; see Aveni and Hartung n.d.); Building J, Monte Alban (Aveni and Linsley 1972).

Standing atop the Tower of the Palace of Palenque or upon Str. IV or V of Tikal, one confronts a scene that represents not only a cross-section in space but also many slices through different points on a time axis in the history of a culture. Structure on structure, one building abuts its neighbors as if to crowd them out. How can we hope to devise a rational set of explanations to account for the skewed alignments we observe? Directional shifts are especially evident at Teotihuacan where we find buildings that conform to two slightly different sets of axes. At Chichen Itza, buildings with the heaviest Toltec influence not only dominate one portion of the center (the north side), but also fall into similar orientation groups (Aveni, Gibbs, and Hartung 1975). Indeed, the Temple of the Warriors resembles its Central Mexican counterpart (Str. B at Tula, the Toltec capital), and also possesses a similar axial alignment (rotated by 90°).

Undoubtedly there must have existed far more instances in which rebuilding, especially in a crowded environment, proceeded simply as a matter of convenience. Thus, it is difficult to explain the skewed eastern foundation of the Great Pyramid at Uxmal (see fig. 5a). Perhaps this facade simply was built in line with the Palace of the Governor, the orientation of which, as we argue later, can be attributed to astronomical factors.

Thus, while we must be careful not to label every oddly shaped building that deviates from a prevailing axial trend as an astronomical observatory, we ought not rule out, without examination, the possibility that the directions of astronomical bodies at the horizon were registered, whether for purely ceremonial reasons or for the purpose of calendrically related observation, or both together, in at least a portion of the architectural planning. Finally, in singling out individual buildings among a group for study, we are forced to deal with the problem of chronology, lest we assume naively and without justification that all the buildings at Tikal or Palenque were erected at the same time according to a pre-ordained grand plan.

These words of caution are intended to cast a realistic tone upon a subject, the complexity of which, we believe, has been underestimated. Yet the study of building orientations must proceed, for there is, in addition to the diagrams presented in figure 1, good evidence from both past and present records to suggest that orientation calendars were important in Mesoamerica. For example, Motolinia tells us that the Aztec Templo Mayor was oriented to the sun at the equinox and that Moctezuma was prepared to tear it down and rebuild it because it was not oriented correctly (cf. Thompson 1974, 95). Among some contemporary Maya of highland Guatemala, shamans still lay out orientations to the sun at the equinox, which, we are told, occurred around twenty days before the time of planting (Lincoln 1942). We shall have more to say about the establishment of solar orientations at twenty-day intervals. Because there is no space to lay a foundation for the supporting ethnohistoric and ethnographic evidence here, the reader is invited to consult Aveni's summary (1980, esp. chap. 2) for details and references that bear upon the astronomical orientation hypotheses.

Systematic alignments, the existence of oddly arranged structures, and cultural evidence—all leave little doubt that astronomical factors played a role in Mesoamerican city planning. Yet, for the reasons cited in this introduction, it is a difficult and complex task to determine precisely how and to what extent information about timekeeping and the sky actually was incorporated into building plans.

THE ORIENTATION OF CEREMONIAL ARCHITECTURE IN ANCIENT MESOAMERICA

Macgowan (1945) appears to have been the first to point out that all over Mesoamerica the axes that define the general alignment of ceremonial centers possess a curious clockwise (east of north) skew from the direction of astronomical north. With data based on actual measurements we made at fifty-six sites, we were able to verify, elaborate, and extend the observations Macgowan made on the basis of published site maps (Aveni 1975). Many elaborations of Macgowan's original work have been made, especially during the past fifteen years (see Aveni 1980, chap. 5, for a summary and reference list). In particular, the remarkable consistency of alignment directions over a wide area and throughout a long time period has invited a host of astronomical explanations.

Teotihuacan provides one of the best examples of large-scale planning and careful orientation of a city. As Millon and colleagues (1973) have shown, the buildings conform to a precise right-angle grid that may have had some slight systematic and deliberate shifting. The grid deviates from the general grain of the local topography, and often the contours of hills and valleys were completely disregarded in the building process. As Millon has suggested, it is as if a religious dictate or concept of order overrode practical considerations. Some of the pecked cross-circle petroglyphs carved into the stucco floors of buildings in the ceremonial center and in rock outcrops in its vicinity may have figured as architects' benchmarks, used in establishing the orientation plan at some stage. When these markers are seen together with the cosmological diagrams (fig. 1), one may compare the similarity of their quadripartite design. The detailed resemblance between the diagram of figure 1a and the marker on the stucco floor of a building at Teotihuacan depicted in figure 1f has been elaborated by Aveni, Hartung, and Buckingham (1975). Astronomical (Dow 1967) as well as non-astronomical (Tobriner 1972, Heyden 1975, Hartung 1979) reasons for the orientation of the site have been proposed. For example, the largest structure at Teotihuacan, the Pyramid of the Sun, was built over a cave, and furthermore, the orientation of the major axis of the site may have been influenced, at least in a general way, by the location of Cerro Gordo, the largest peak in the immediate vicinity and the primary source of water.

Whatever motive lay behind the orientation of Teotihuacan, it stands as the source of a long and lasting tradition, commensurate with the ceramic, artistic, and iconographic influence it cast upon other Mesoamerican civilizations to follow it. The 15½° E of N orientation of the Teotihuacan grid

FIG.2a PAN–MAYA

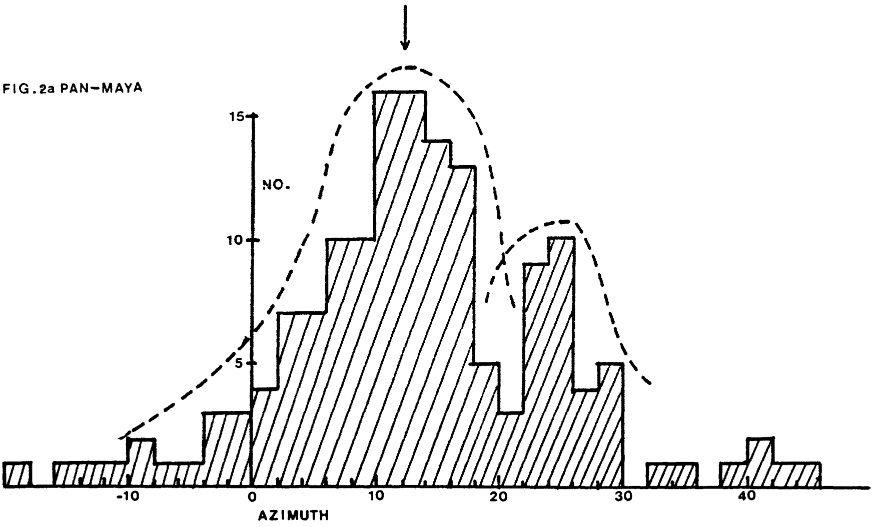

FIG. 2. Histograms showing distribution of major building alignments in Mesoamerica (arrow indicates median).

FIG. 2a. All Maya: Transit measurements by Aveni & Hartung, made in field seasons of '71, '73, '76, '80, '84, '86.

may have been copied in other centers around the Valley of Mexico (Aveni and Gibbs 1976), many of which can be dated to a millennium or more after the foundation of Teotihuacan. This raises the question of whether the Toltecs and later the Aztecs might have inherited particular ideas about building orientation and calendar from their predecessors. Specifically, there is some evidence that certain alignments postulated at Teotihuacan also existed in Tenochtitlan, the Aztec capital (Aveni and Hartung 1982a). On the other hand, pre-Teotihuacan buildings appear to be oriented quite dif-

FIG.2b CENTRAL MEXICAN

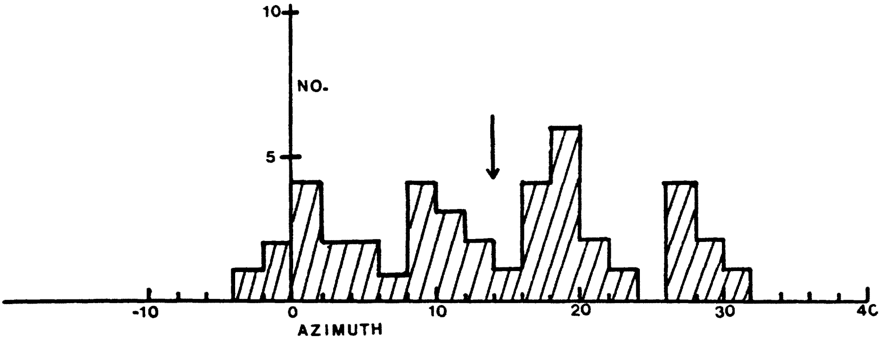

FIG. 2b. Central Mexico: Aveni & Gibbs (1976), with transit measurements made in '80, '84, '86 added.

FIG.2c PUUC

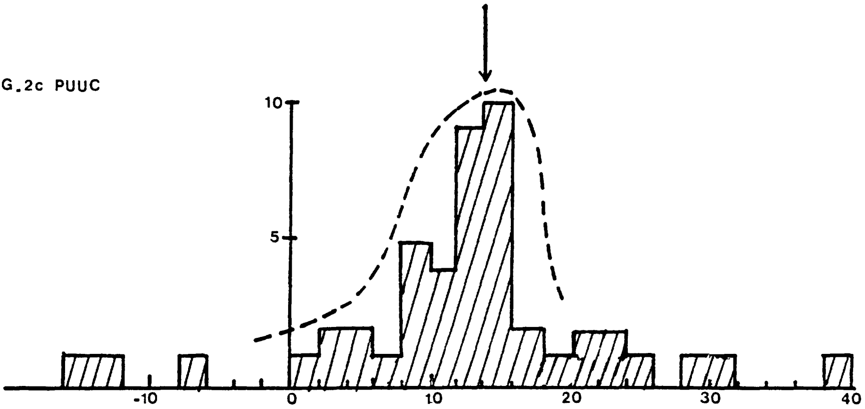

FIG. 2c. Maya: Puuc (Regional Definition).

ferently. Thus, Olmec ceremonial centers have axes deviating to the west of true north (Aveni 1980, 236).

What sorts of data are necessary to study building alignments? As we have pointed out, one ought not rely upon alignment directions gleaned from site maps, for usually the archaeologist is not concerned about providing the precise sort of directions required in astronomical studies. Frequently, particularly on the older maps, no correction from magnetic to true north is indicated (the two can differ by up to 10° in Mexico) and there are numerous instances in which the magnetic readings are affected by local anomalies. Some alignment data based upon map measurements are, however, retrievable with an error of less than 1°. For example, we have measured with the surveyor's transit and astronomical fix the alignments of thirty-three buildings that also were measured with the magnetic compass and corrected to true north by Dursin (n.d.). We found an average deviation of 31 minutes of arc (±10′ standard deviation) between the two data sets. (We discounted two readings for which the difference was in

FIG.2d LATE FORMATIVE/EARLY CLASSIC

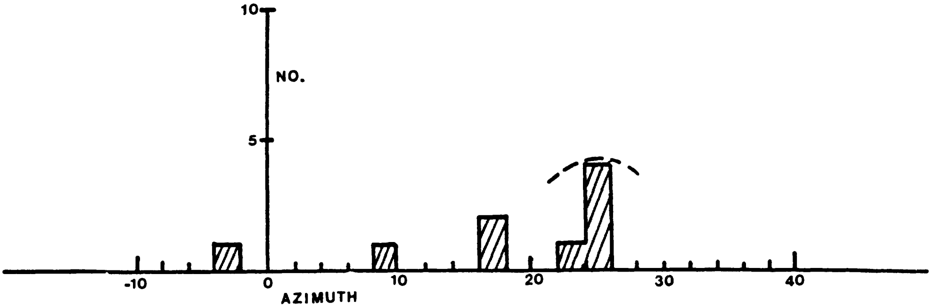

FIG. 2d. Maya: Late Formative & Early Classic.

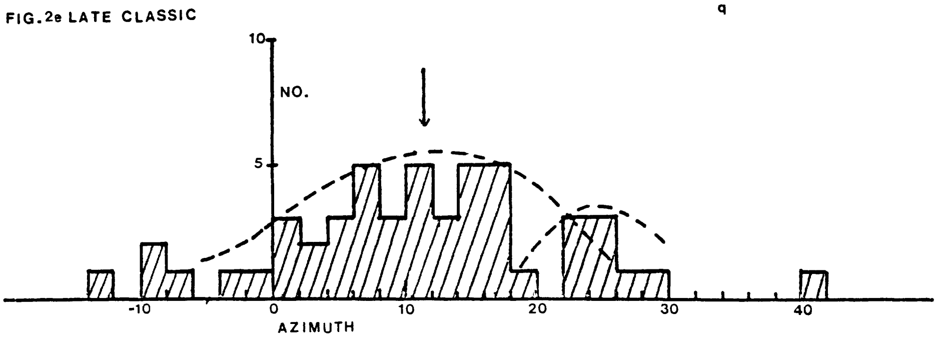

FIG. 2e. Maya: Late Classic.

excess of 2°.) By applying the same comparative technique to the orientations of sites and buildings determined by magnetic compass and reported in Pollock's monograph on the Puuc (1980), we have been able to render most of his data usable within the bounds of a 1° tolerance.

The study of Maya building orientations presents a special problem because site plans at first glance seem so chaotic. Often buildings deviate markedly from one another and large orientation shifts in different building phases of the same structure are quite common. Beguiled by these asymmetries, Thompson seems to have paid little regard to the possibility that the Maya might have had some rationale in orienting their buildings. Without carefully examining these structures, he offered the explanation that variations from right angles were likely caused by sloppiness on the part of the builders (1974, 94). On the other hand, in our comparative study of the precision in the alignments of modern buildings as opposed to ancient buildings at Palenque and Uxmal (Aveni and Hartung 1982b), we demonstrated that the longer front and rear walls of Maya structures, those which incorporate the facing directions of the structures, were laid out with the same order of accuracy as comparable walls of modern buildings (cf.

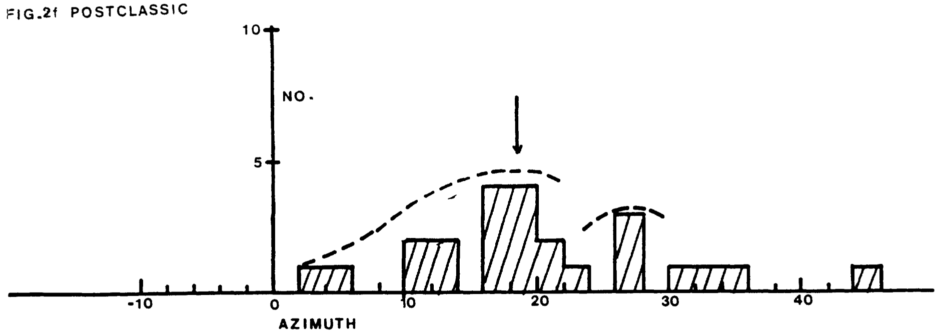

FIG. 2f. Maya: Post-Classic (Early & Late combined).

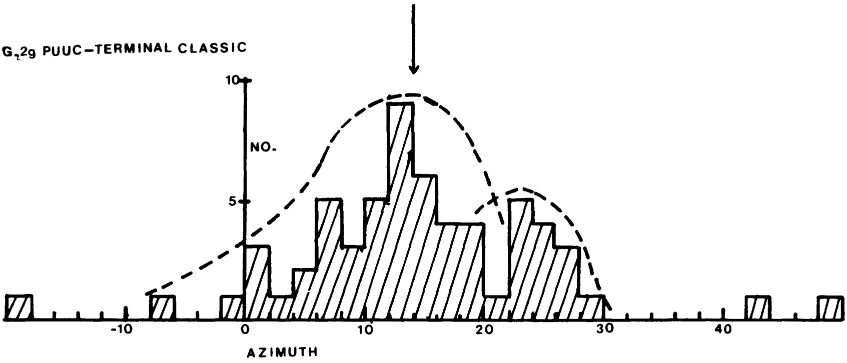

FIG. 2g. Maya: Puuc (Terminal Classic).

fig. 6c). We concluded that axial deviation of many Maya buildings is likely deliberate.

We begin the present analysis by updating and refining our earlier alignment histogram (Aveni 1975, fig. 1). In figure 2a are the alignment directions we have collected for all the Maya buildings, while figure 2b is a sample from Central Mexico alone. In figures 2c through 2g the Maya data are divided into chronological periods given in the explanations to Table 1.

In these histograms the vertical axis marks true north, or 0° true azimuth. The arrow in each plot marks the median direction computed for the sample. All data entered in the histograms for the Maya sites, with which we are concerned primarily in this report, are presented in Table 1. While the statistical sampling in a number of chronological subclasses seems too small to provide much detail about temporal differences, the separate pair of regional histograms (a and b) is sufficient to demonstrate both the universality of the clockwise skew throughout Mesoamerica and the distinct difference between Maya and Central Mexican building orientations.

GENERAL ALIGNMENT OF MAYA SITES

On the map of the Yucatan peninsula (fig. 3), we indicate the facing directions of all 180 buildings at the eighty-one Maya sites where we have collected data with the transit. These represent the so-called "accurate" alignment data. In the histograms we also include an additional forty-one alignments taken from maps of fifteen other sites. One averaged entry per site is given on the map except in cases where different complexes of buildings at a given site have markedly different alignments. At Copan, for example, the site plan can be broken down into three general zones with different alignments (Aveni 1977, 10):

Area I	Great Plaza & Ballcourt—structures at north side of site	6°–7°E of N
Area II	Hieroglyphic Stairway—midsite structures	0°–2°E of N
Area III	Eastern and Western Courts of the Acropolis, T22, and structures at south end of site	7°–9°E of N

A similar sort of breakdown into three or four alignment groups can be found at Chichen Itza (Aveni et al. 1975). Therefore, rather than plotting all alignments for the larger sites in figures 2 and 3, we have attempted to minimize the confusion by displaying only the general alignments of major complexes of buildings. Also, chronology is not considered in figure 3. Furthermore, in the histograms we show the distribution of alignment directions folded about true north. Thus, if a building faces azimuth 99° (9°S of E), it is plotted on the graph as 9°E of N, i.e., its axis is skewed clockwise 9° from the north.

Figure 3 vividly illustrates the dominant clockwise skew already referred to in Mesoamerica in general. All the alignments, which are represented by long arrows at major sites and by short arrows at the lesser sites, exhibit this skew in both the lowland and highland areas. In the relatively flat plain of north Yucatan, where topography might be expected to impose a minimal influence on site planning, the skew seems especially uniform. Late Classic sites on the east coast are, however, possible exceptions, in that a large number of structures face the open sea and appear to be situated nearly perpendicular to the shoreline. Examples include Tulum, El Meco, and buildings along the coast of Quintana Roo between these sites, as well as the small buildings that dot the east coast of Cozumel Island. The alignment of the round tower at Paalmul is a remarkable exception to the east

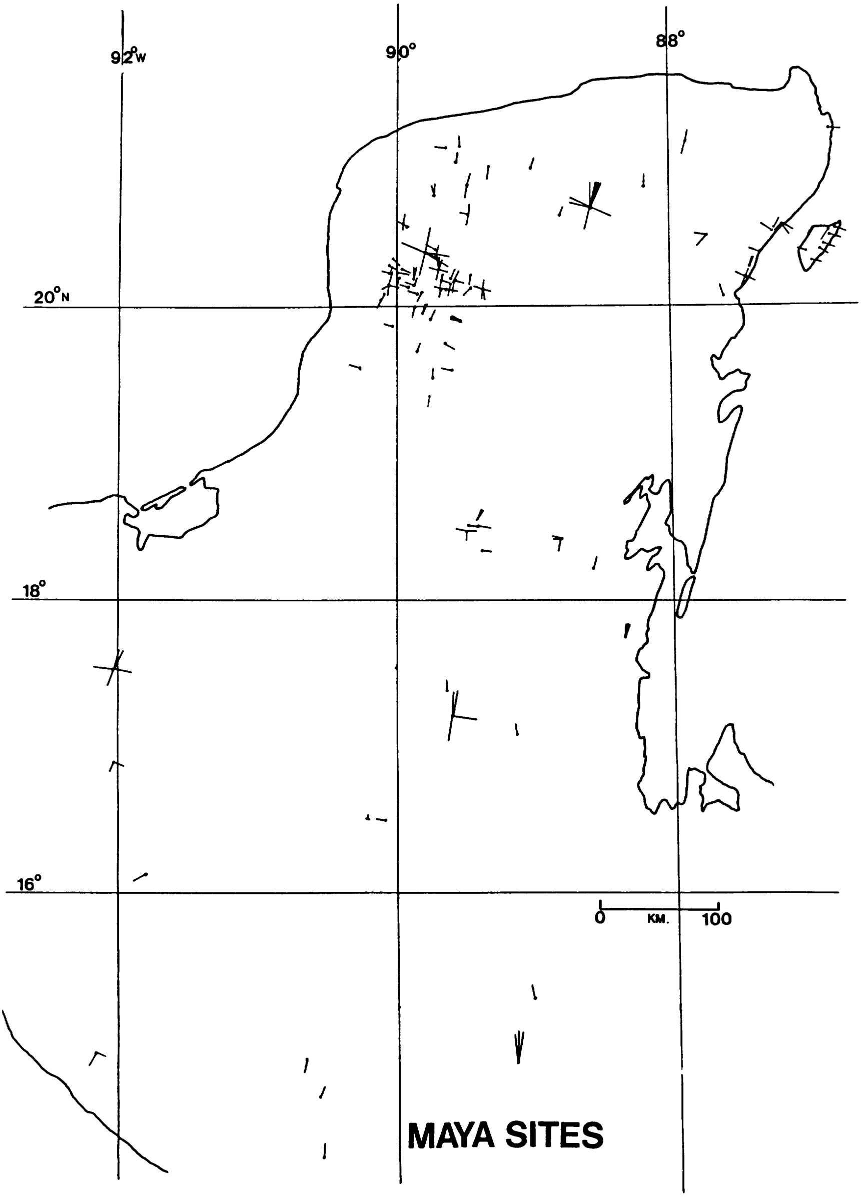

FIG. 3. Map of Yucatan peninsula showing site locations and principal alignments (long arrow = major site; short arrow = minor site).

coast sample; it faces west of north and looks away from the sea. Long before the present survey was completed, Aveni and Hartung (1978) had argued that this structure was oriented astronomically. We believe it may have been modeled after the Caracol of Chichen Itza both in form and function.

The histogram (fig. 2a) reveals the east of north bias in a more quantitative way than the map. Thus, 16 percent of the alignments fall west of the north-south line, while 84 percent lie to the east. The dominant group occurs in a zone 8°–18°E of N. Peaks appear at about 14° and 25°E of N; the median for the entire group resides at 12½°E of N. As stated above, this diagram may be compared to a more general earlier one given by Aveni (1975, fig. 1) containing orientation data for fifty-six pan-Mesoamerican sites, about one-third of which were Maya. The remarkable similarity of the two distributions, as well as the general likeness between the diagram for the Maya sites and the comparative Central Mexican sample, suggests that the clockwise skew in building orientations was standard architectural practice over a wide region of Mexico.

The pronounced 25° maximum for the Maya zone and the 27° maximum for the Central Mexican alignments (fig. 2b) may reflect orientations to the horizon positions of the sun at the solstices. If we postulate sunrise at December solstice as the guiding principle, then we might expect the highland alignments to peak at slightly higher values than their Maya counterparts because the elevated horizon in the former region would result in a shift of the appearance of first sunlight toward slightly higher azimuth values.

Examining the data chronologically, one notes that this basic orientation to one of the key positions of the sun at horizon is already present in Late Formative/Early Classic architecture (see fig. 2d) and that it persists in the Late Classic period (fig. 2e). By the Post Classic, however (fig. 2f), its presence is not so obvious. On the basis of glyphic and ethnohistoric evidence, Bricker (1982) has argued that the solar calendar was first employed by the Maya about 550 B.C., i.e., during the Middle Pre-Classic Period. Her arrangement of month names according to the seasonal year suggests that the winter solstice was originally chosen as the starting point of the year count. This conclusion is consistent with our histogram (fig. 2d), which shows the earliest structural alignments beginning to be built up in the solstice direction. However, as we can see in figure 2c, by the time the Puuc style of architecture had developed, some 1300 years later, a decidedly different orientation principle was at work.

Thus, our large sample of data offers an excellent opportunity for regional studies of orientation. Some of our best alignment data were gathered at the Terminal Classic Puuc sites of North Yucatan. Here, the confinement of the sites to a relatively narrow time-space provenience, combined with the relatively satisfactory condition of preservation of many of the buildings, offer the possibility of a more refined analysis.

PUUC BUILDING ALIGNMENTS

Today, the Puuc hills of northwestern Yucatan are among the most sparsely populated regions of the peninsula, yet the density of ruins dating to the Terminal Classic Period of the Maya culture serves as testimony to its relative prominence. Kurjack and colleagues (1977) observe that practically all Puuc sites are located near relatively fertile land, a factor that may have helped the Maya decide where to build their centers of worship. Perfectly cut stone, decorated, laid out, and filled in a simple yet elegant way on a modest scale, typify the characteristic Puuc-style architecture which has been regarded by some investigators as the finest in the Maya world (Gendrop 1983).

As a geographic zone, Puuc is defined as the hilly, karsted, riverless, topography that is enclosed in an acute angle subtended by a pair of ridges, averaging a hundred meters in height above the plain, that converge at the northwestern Yucatecan town of Maxcanu near Oxkintok (see fig. 4). From that point, the Sierrita de Ticul, or so-called Puuc Range, runs about one hundred and fifty kilometers to the southeast, while the southwestern (unnamed) ridge runs about the same length, terminating near the city of Campeche. (See Pollock, 1980, 2–6 and references therein, for a discussion of the ecology of this region.)

Most of the ruins cluster tightly in the northwestern portion of this area, within the Yucatan state border, hugging the Sierrita de Ticul. The majority of these are confined to the Puuc Florescent or Terminal Classical Period (800–1000 A.D. [Andrews V 1977, 5; Pollock 1980, 562]), though there are some Early Puuc structures that may date back to the seventh century. For the sake of simplicity, we focus on the *regional* rather than the *stylistic* definition of Puuc, thus we excluded sites such as Ekbalam, Culuba, and certain buildings at Chichen Itza which, though they exhibit Puuc iconographic and architectural features, are located far to the east of the Puuc hills. Though we begin by referring to orientations of sites in the Puuc region in general, later we comment on the possibility of dealing with the chronology of Puuc building orientations. In figure 2c we show general alignments of thirty-two sites of the Puuc region. Once again, the bump that was present in the pan-Maya histogram at 14° is in evidence, though the 24° peak has vanished. The median for the Puuc group is 14° and the standard deviation about the mean, ±4°, is a good deal smaller than that for the pan-Maya sample. Ninety-three percent of the structures are skewed clockwise, only 7 percent counterclockwise. As usual, practically no buildings are aligned north-south, although, as we shall see later, certain aspects of the layout of a Puuc site often exhibit a north-south trend.

The sharply focused histogram of figure 2c may be compared with that of figure 2g in which we have included data on all measured structures in the Yucatan defined as Puuc purely on stylistic grounds rather than on location in the Puuc region of the peninsula. The 14° median peak is much less sharply focused in figure 2g and the admixed, possibly earlier tradition of solstitially-oriented buildings is evidenced by the peak at azimuth 23°. This vivid comparison suggests that the Terminal Classic sites in the Puuc zone adhere both single-mindedly and rigidly to a common orientation principle.

The sketch map of figure 4, an enlargement of a section of figure 3, shows clearly that the exceptions to the clockwise skew are few in number. The east of north trend is displayed not only in the central Puuc zone, between Uxmal and Sayil, but also at sites far to the southeast of this region and at remote Oxkintok, which is tucked in between the juncture of the Puuc ridges south of the town of Maxcanu.

As Pollock and other archaeologists have noted, the civic plans of many of the larger sites in this area are similar in at least three regards:

(a) the buildings often are grouped about a general north-south axis;

(b) the buildings in a given complex often face inward toward the center of that complex; and

(c) there is a tendency "for single structures and larger architectural complexes to face toward the ceremonial or civic center of the site" (Pollock 1980, 652).

Buildings that look outward away from either the site center or the general axis are extremely rare.

While Pollock repeatedly comments on the clockwise-skewed axiality of Puuc ceremonial architecture, he gives possible reasons neither for it nor for how such a consistent absolute alignment might have been executed by the builders of different sites. Nonetheless, he seems to have appreciated both the extent and the acuity of the directional angular confinement of the alignments:

> Certainly the dominant principle in the orientation of Puuc architecture was that one of the principal axes of any structure should fall somewhat east of north. This is so consistently true that the occasional exception is notable. The extent of the deviation from true north varies not only between sites but between structures at any one site. It is most often, I think, a matter of a few degrees, but 20° or more is not uncommon and there are examples of over 30° (Pollock 1980, 562).

For the historical record we should point out that long before Pollock, Morley was aware of a systematic trend in the axes of orientation of Lowland Maya ceremonial structures, though he seems rather hastily to have assigned a particular astronomical motive to the phenomenon. Writing to Bowditch in 1909 he stated:

> Though I only worked one night at Kabah, I found out that the building in which we camped (Casa No. 1, Stephens) also ran East of North as did all the other houses

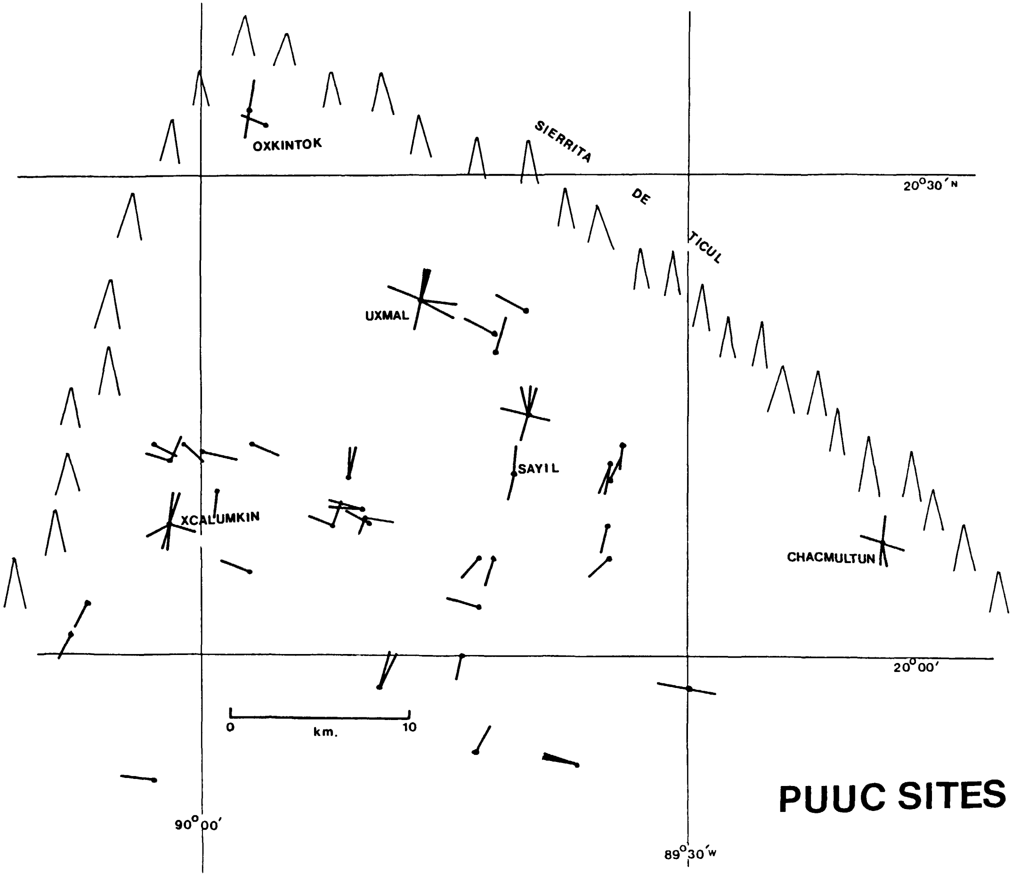

FIG. 4. Enlargement of Puuc zone shown in figure 2 to illustrate minor site alignments.

> examined at Chichen Itza and Uxmal. Moreover, judging by eye from this building as far as I could make out all the other buildings at Kabah, twenty in number at least, also are now east of north in their orientations. Should this be found true at other sites in Yucatan I believe we are near to establishing the point that a north star orientation was practiced by the ancient priest-rulers (letter to Bowditch, 17 July 1909).[1]

Later in the same letter he speculated on the possible use of orientation data to test hypotheses about Maya-Christian calendar correlation.

By presenting the data on the Puuc sites in various forms, we have been able to establish that an orientation problem exists, i.e., these structures exhibit a systematic trend in alignments that requires an explanation. But to begin to solve the problem, we must examine the alignment data in greater detail. Stated in simple terms, the questions to confront next are:

(a) Why are the axes of nearly all Puuc buildings confined to a narrow range of orientations centered about a direction skewed 14° clockwise from the true cardinal directions; and

(b) What, if anything, does this "14° Puuc habit" have to do with the general east of north (clockwise) trend exhibited by buildings all over Mesoamerica for more than a millennium-and-a-half from the earliest periods of the Teotihuacan culture up to the time of the Conquest?

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[1] We are indebted to Lucy B. Putnam for permission to quote and to C. M. Hinsley of the History Department at Colgate University for bringing this letter to our attention.

DISCUSSION OF INDIVIDUAL SITE PLANS

UXMAL (figs. 5a, 6, 7, 8, 9)

Like the civic plans of the other major ruins in this area, Uxmal, perhaps the largest and certainly the most famous Puuc site, is constructed about an imaginary "axis" that deviates in a slightly clockwise sense from the cardinal directions (see figs. 5a and 9a). While no visible causeway can be found in the remains of this major Puuc site to connect the structures that comprise the poles of the axis, one cannot exclude the possibility that formerly there was some sort of plaza, causeway, or other ceremonial space relating the extreme southerly and northerly structural groupings. Determining the bearing of this axis in the field is not as easy as it might appear; it is difficult to define the precise center of the North Group, which today lies in a ruinous state (see fig. 9a, a photo taken along the south-north axis). An approximate bearing with the transit yields 13°E of N, a result consistent (to within ½°) with measurements we made on Morley's map (Pollock 1980, fig. 389, p. 210) after we had corrected it to correspond to transit measurements we made on the bearings of various buildings taken from several vantage points at the site. The level character of the local topography is broken by a few low outcrops of bedrock which do not influence the arrangement of the buildings (Pollock 1980, 208).

Thus, the line from the center of the largest pyramid of the North Group (fig. 9b) to the center of the South Temple of the South Group (H) (fig. 5a) bears 13°–193°; these two complexes define the northerly and southerly extremes of the central portion of the site and they also face one another. The buildings flanking this imaginary axis also align quite closely with it; the Ballcourt (C in fig. 5a) deviates by ½°, the Lower Temple of the House of the Old Woman (F) by 1½°, the buildings of the North Group (M) by 2°, those of the South Group (I) by 1°, the West Building of the Cemetery Group (K) by 1°, and the Great Pyramid (G) by 2° (precise data are listed in Table 1). The Pyramid of the Magician (B) exhibits a slightly larger shift from the general plan (4°), but the two most notably disoriented buildings at the site are the Palace of the Governor (E) and portions of the Nunnery (A). For both the latter, Aveni (1975) and Aveni and Hartung (1982b) have argued that a deliberate deviation was sought for special purposes. These arguments are worth reviewing briefly here.

Constructed on a large artificial platform about two hundred meters on a side, the Palace of the Governor (E) deviates in a clockwise direction by 15° from the main axis of the site; the building faces 28°11'S of E; therefore,

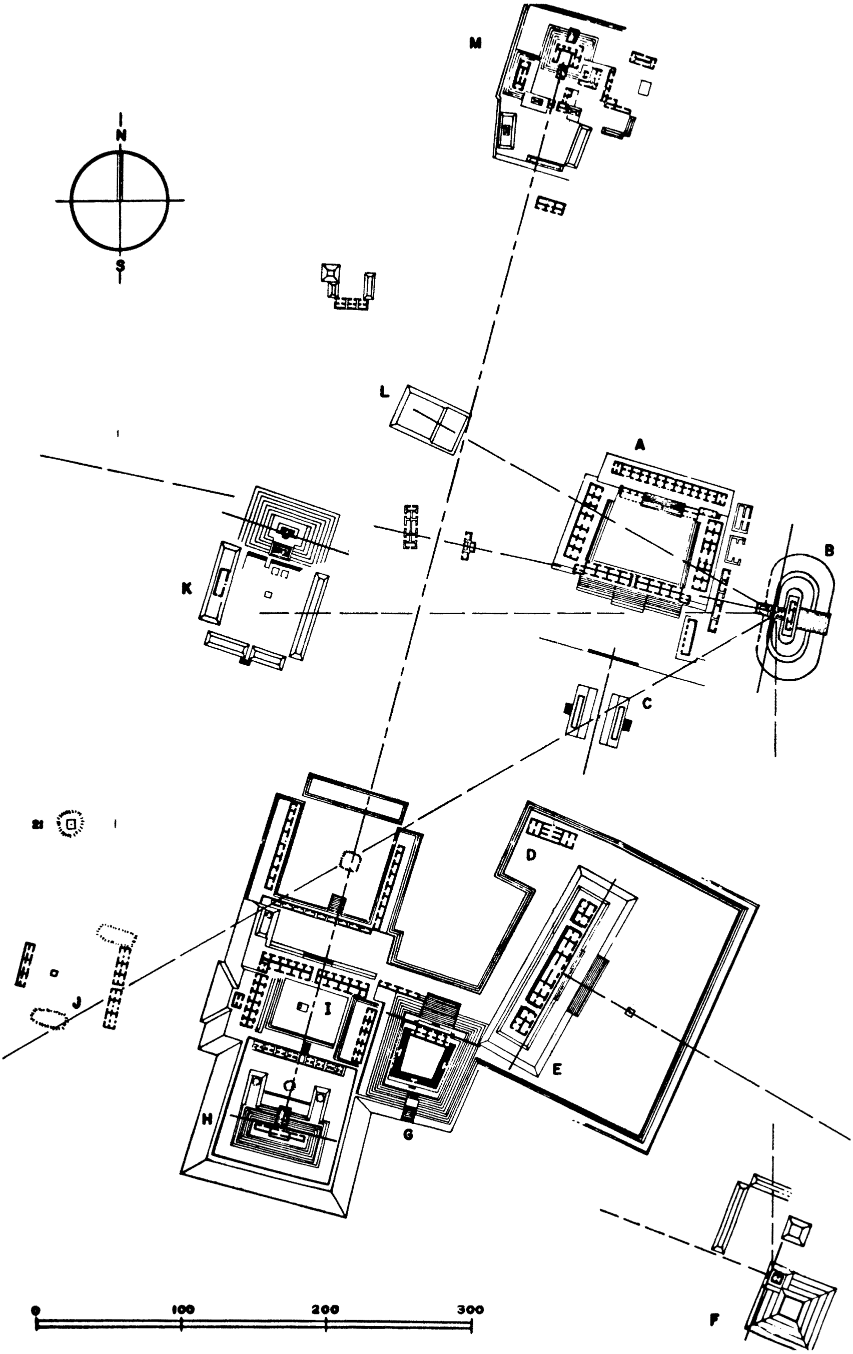

FIG. 5. Plans of selected Puuc sites.

FIG. 5a. Uxmal.

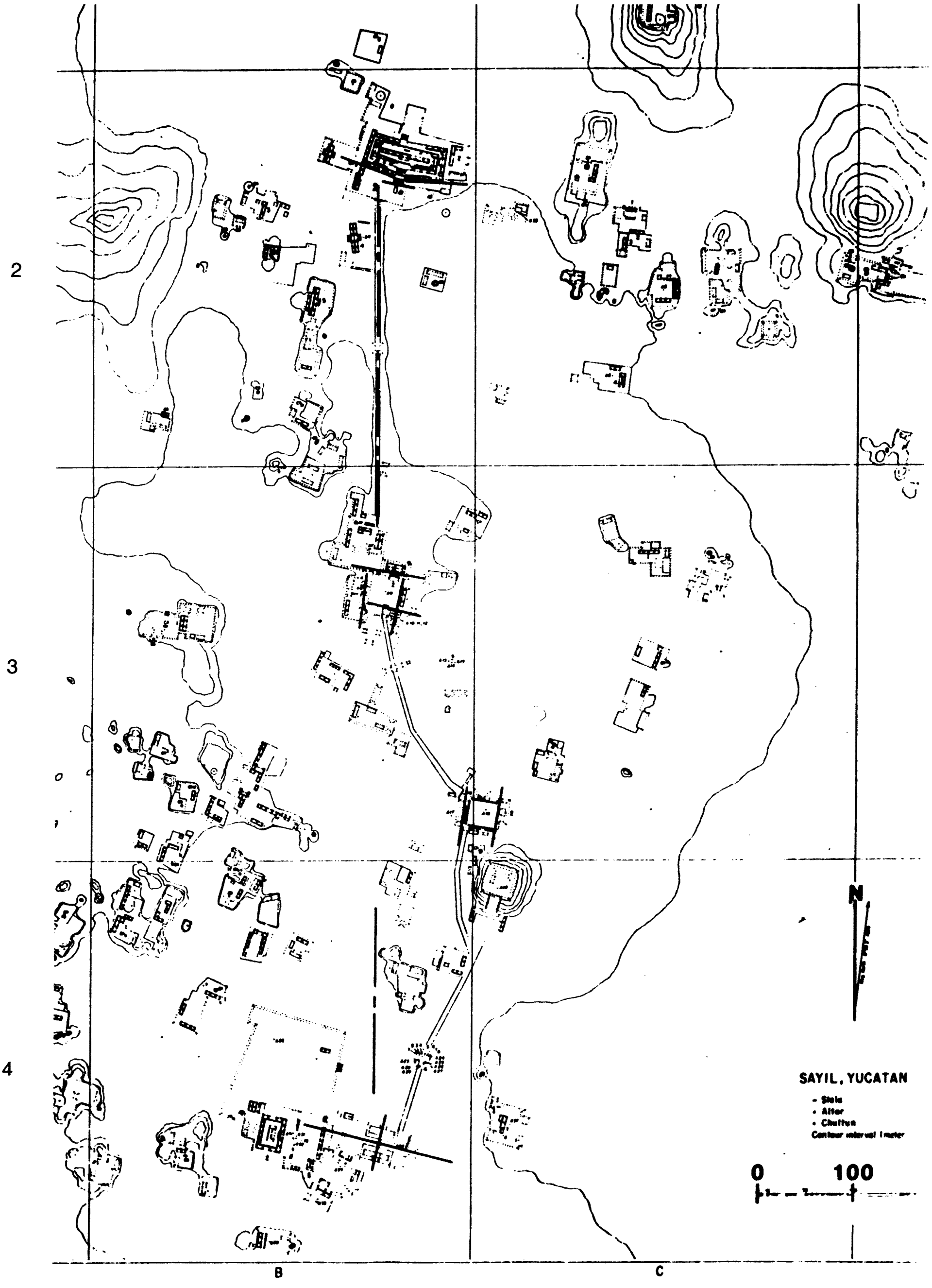
2
3
4
B
C
N
SAYIL, YUCATAN
- Stela
• Altar
• Chultun
Contour interval 1 meter
0
100

FIG. 5b. Sayil.

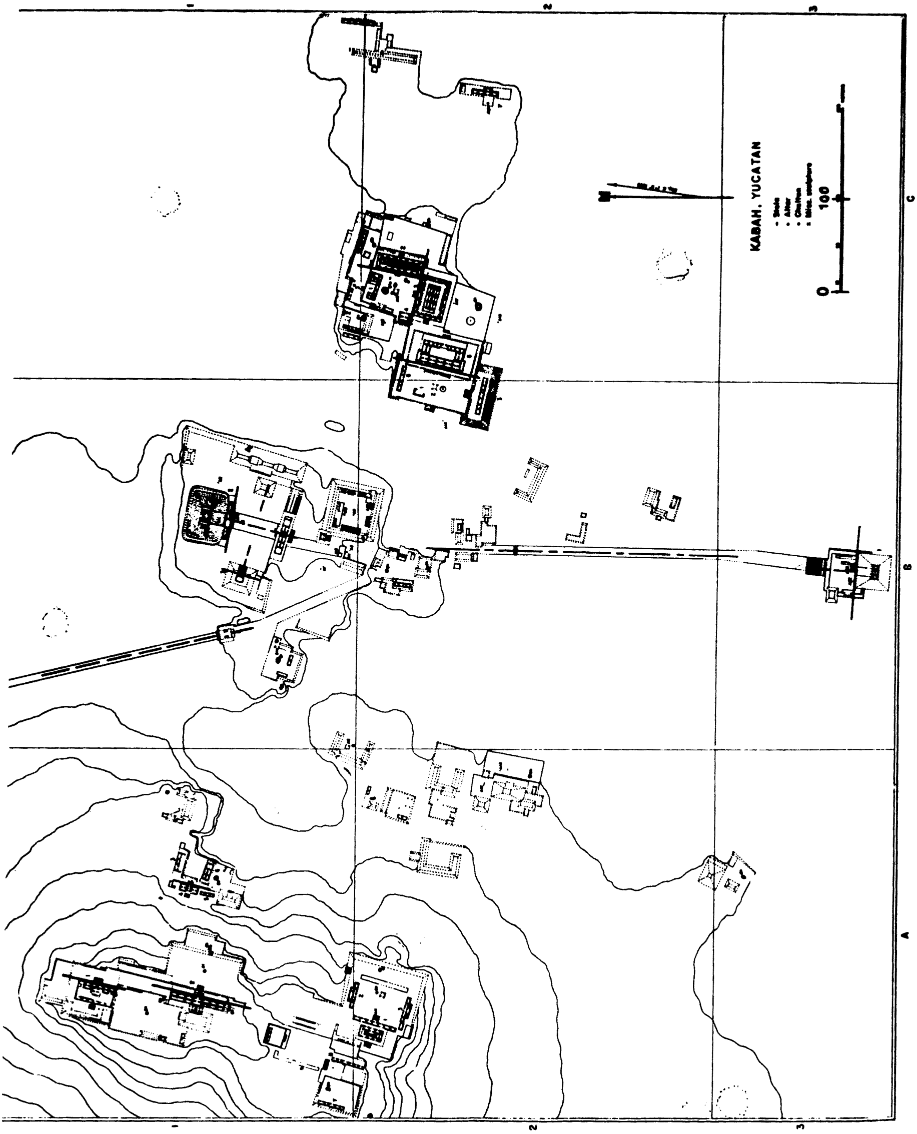
KABAH, YUCATAN
Stela
Altar
Chultun
Misc. sculpture
0
100
N
1
2
3
A
B
C

FIG. 5c. Kabah.

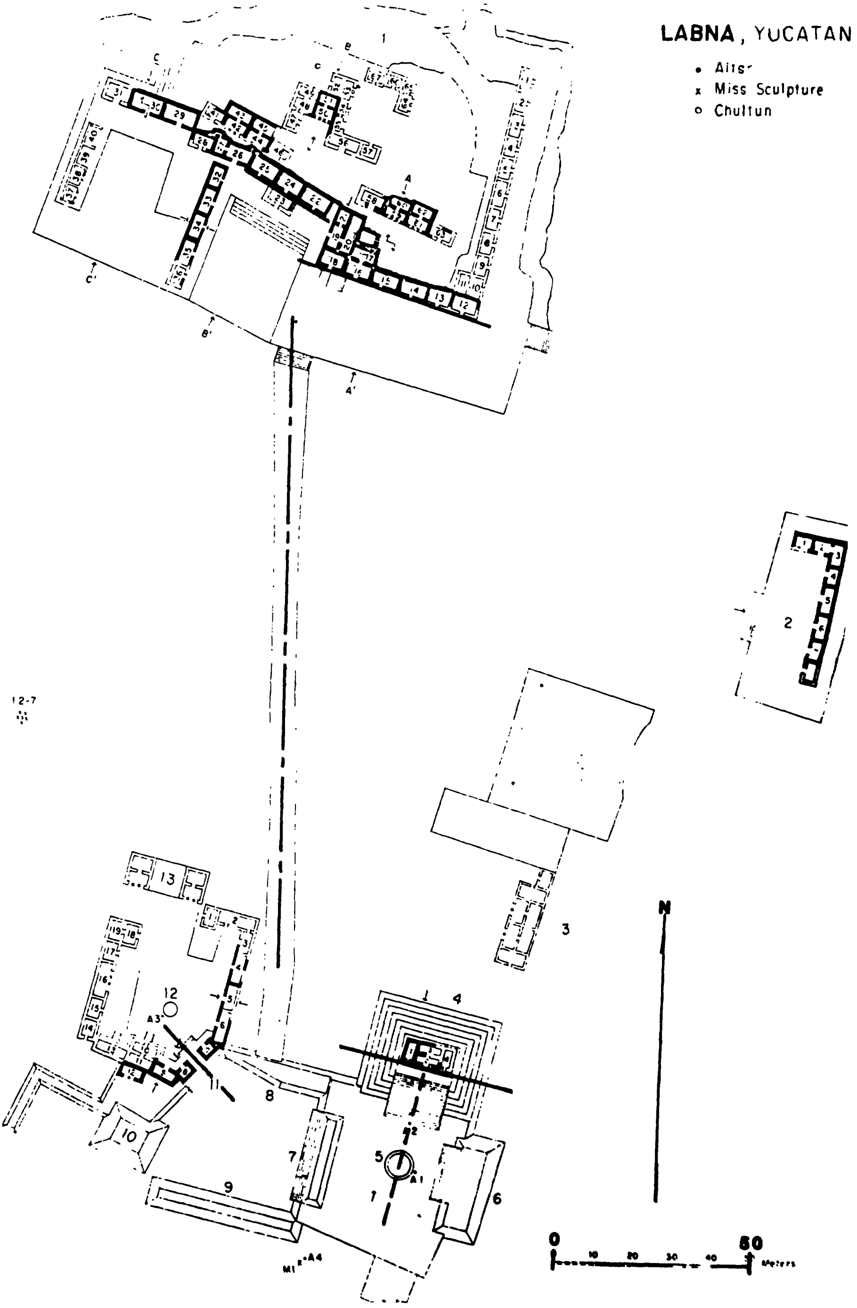
LABNA, YUCATAN
• Alts
x Miss Sculpture
o Chultun
1
2
3
4
5
6
7
8
9
10
11
12
13
A
A'
B
B'
C
C'
A1
A2
A3
A4
M1
12-7
N
0
10
20
30
40
50
Meters

FIG. 5d. Labna.

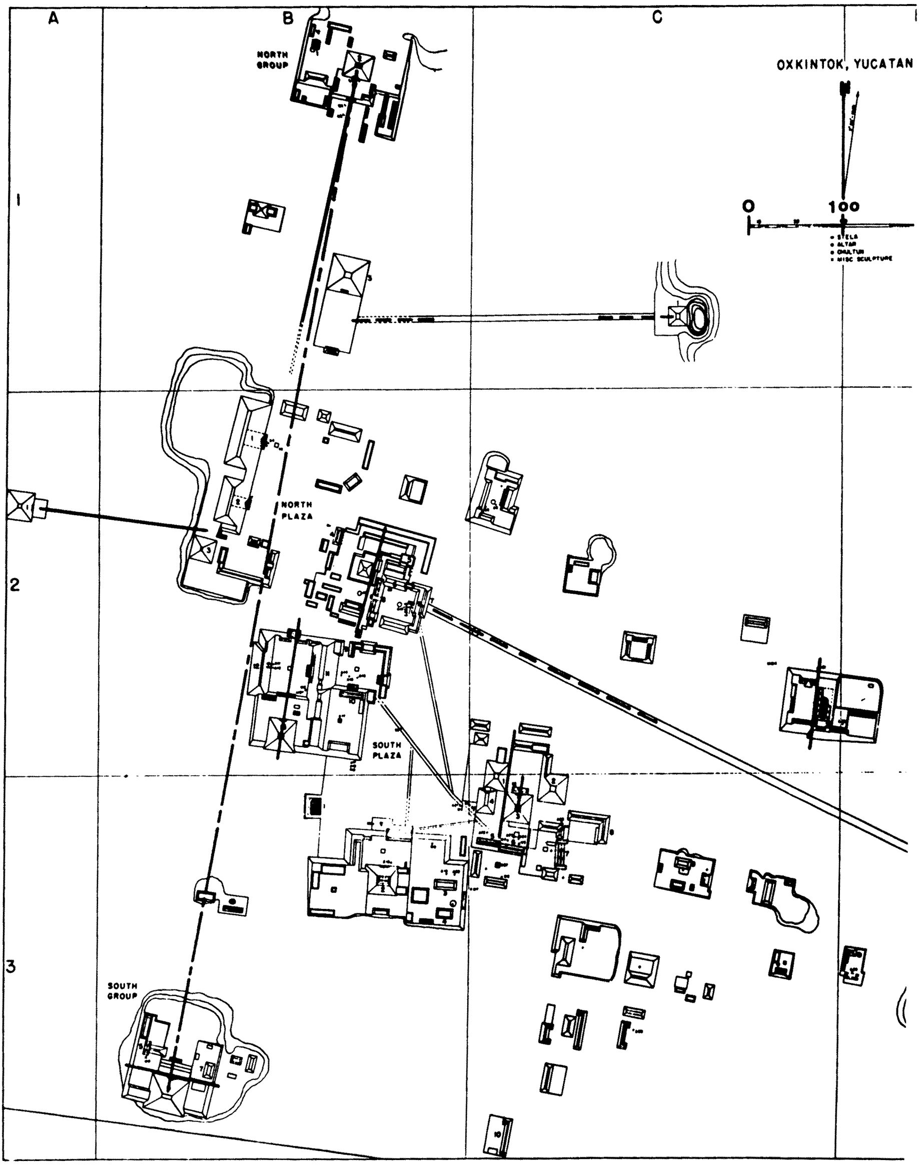

FIG. 5e. Oxkintok.

not only is it skewed, but also it looks out away from the center, with its back toward the site axis. (Compare figs. 6a and 6b, photos taken from either side of the building; the alignments are indicated in the plan of fig. 6c.)

The central doorway faces precisely toward the largest structure at the neighboring site of Nohpat six kilometers distant (fig. 6d), but the direction also points to the southernmost rising position (i.e., standstill) of the planet Venus, an astronomical body which the epigraphic record suggests the

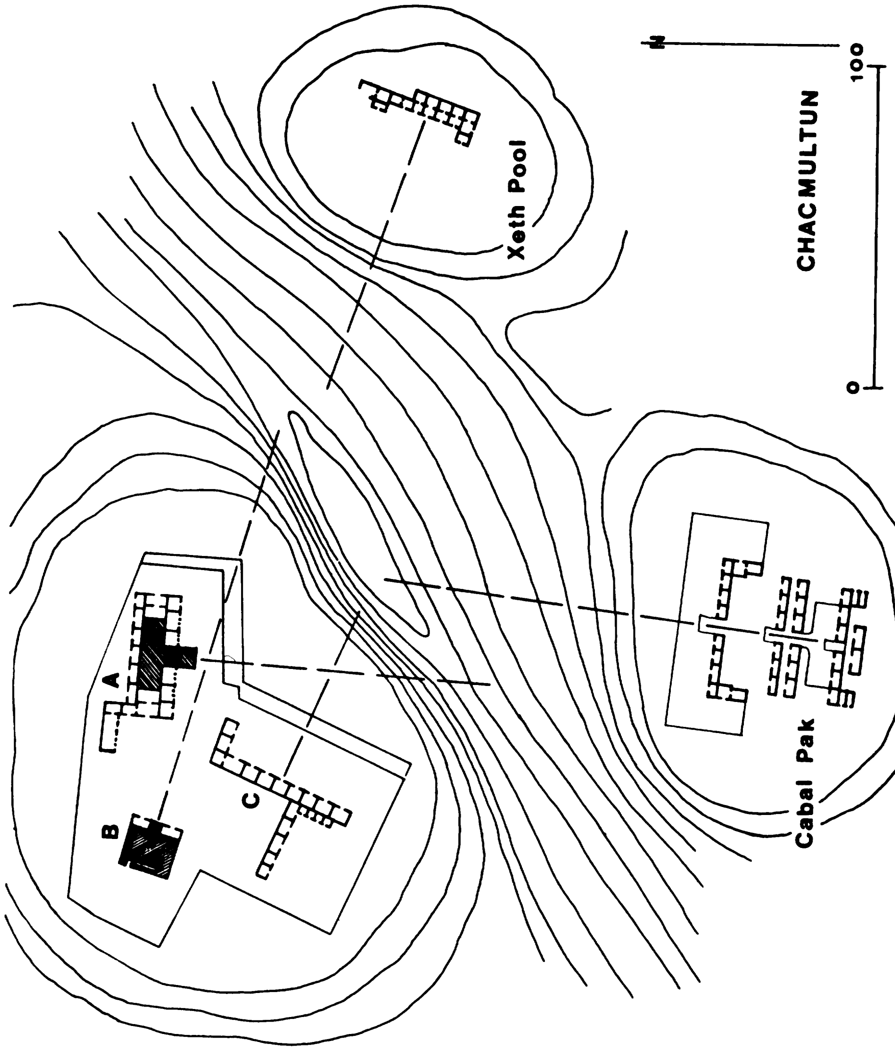

FIG. 5f. Chacmultun.

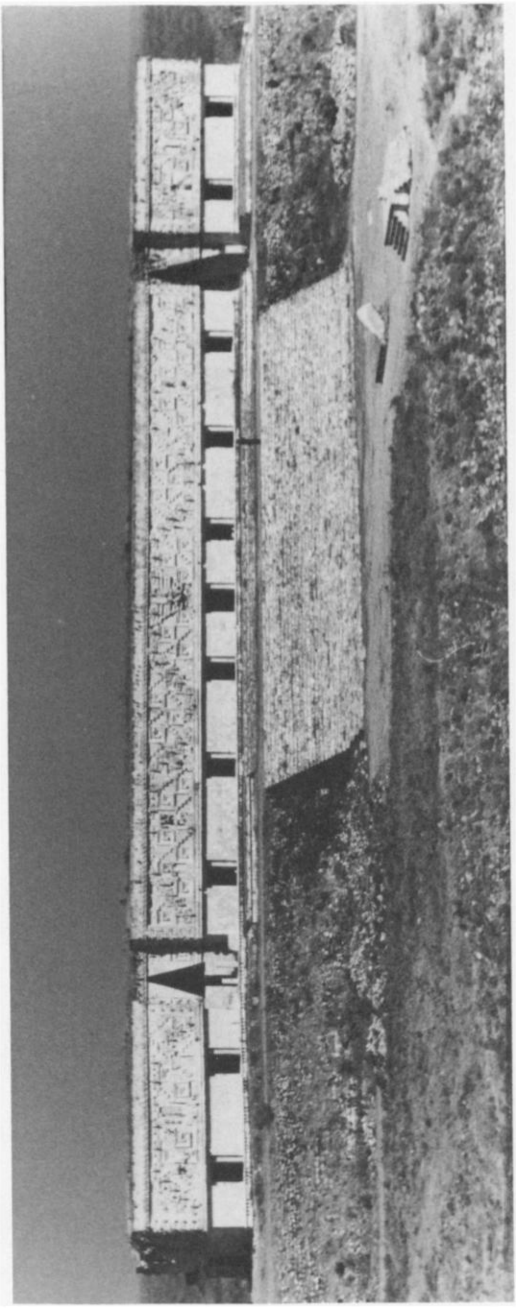

FIG. 6a. Uxmal: Palace of the Governor; front (eastern) facade (top).

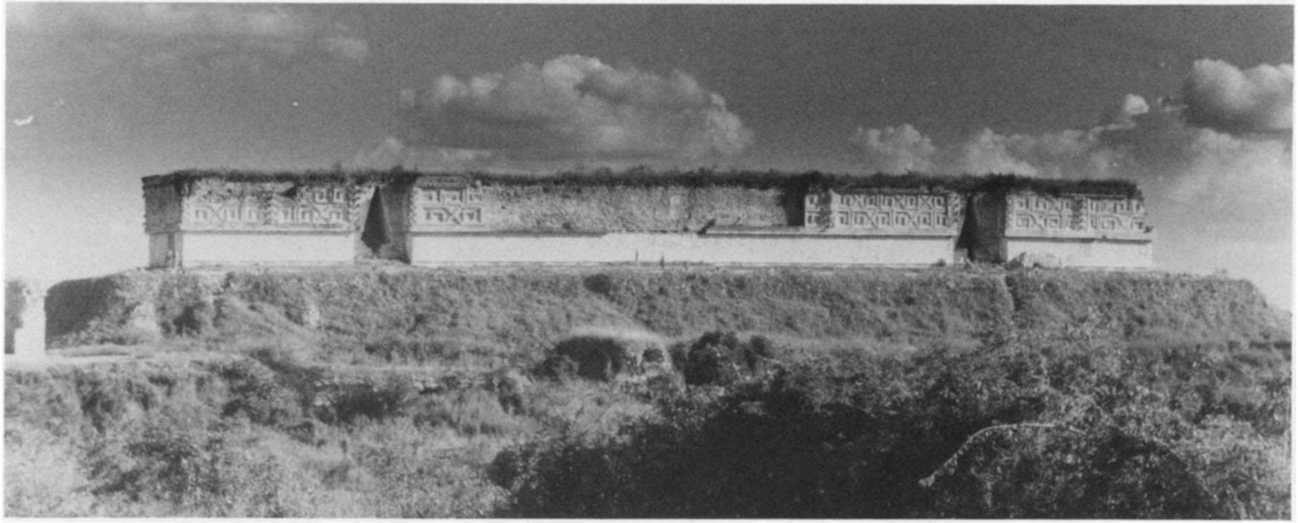

FIG. 6b. Uxmal: Palace of the Governor; rear (western) facade (below).

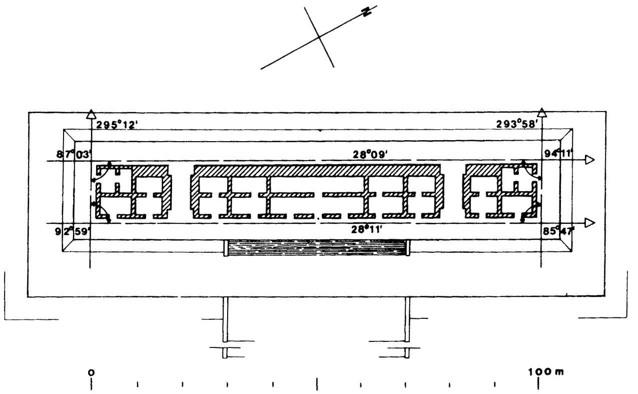

FIG. 6c. Plan of Palace of the Governor with wall orientations and angles between walls labeled.

Maya watched very carefully (Thompson 1974). This particular astronomical explanation for the orientation of the Palace of the Governor is supported by information derived from the iconography present on the building. More than 350 Venus hieroglyphic symbols (T510) (Thompson 1962, 108) appear on the upper facade of the building (Hartung and Aveni 1982, fig. 9) (see fig. 6e here). Also, a possible representation in Maya dot-bar notation of the mean disappearance interval of this planet about inferior conjunction (eight days in the Dresden Codex) is sculptured over the eyes of the Chac masks on the northeastern and northwestern corners of the uppermost platform of the building (fig. 6f). According to the Venus Table in the Dresden Codex, a Maya written document, it is precisely after a disappearance interval of eight days that one would expect to see Venus rising in the east. Closs, Aveni, and Crowley (1984) have discussed the Chac-Venus association and offer more examples of Maya buildings at other sites that were likely oriented to anticipate the disappearance and reappearance of the bright planet.

These observations may be of special significance because the Chac masks on the facade of the Palace of the Governor are the only ones at Uxmal that bear the Venus hieroglyph as a decorative element (see Foncerrada's study of the sculpture at Uxmal [1965], where the types of masks found are illustrated and discussed). Searching through Hissink's (1934) study of the masks, which was conducted throughout the Puuc zone, we failed to turn up a single example outside Uxmal that exhibited the T510 glyph as part of the design; however, we did observe that some of the masks on the north side of the Nunnery at Chichen Itza (the facade facing the Caracol) exhibit the Venus symbol. Like the masks on the Palace of the Governor, these were arranged in groups of five, in agreement with the format of one Venus cycle per page of the Dresden Table. We have found no other Chac mask that bears the numeral 8.

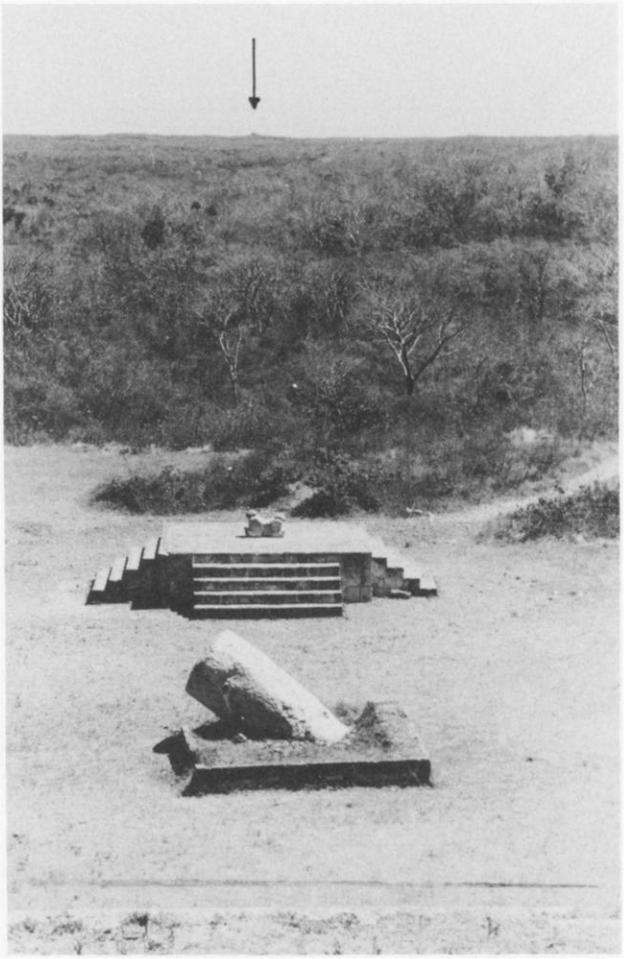

FIG. 6d. View perpendicular to the doorway of the Palace of the Governor to the pyramid of Nohpat (arrow).

Though we reported the Venus orientation and the supporting evidence in the existence of the numeral 8 and T510 designs on the decorative elements on the Palace of the Governor relatively recently, over half a century ago Seler (1917, 112) already had hypothesized on iconographic grounds that the building was associated with worship of the planet Venus, known to have symbolized Quetzalcoatl-Kululcan in the Mesoamerican pantheon. It is worth mentioning that while Seler recognized the skewed alignment of the Palace of the Governor from the general plan of Uxmal (1917, 121), he suggested that it might be caused by a natural feature under the buildings. He was apparently not aware that the skew could be attributed to a Venus orientation manifested by sightings made from the central doorway of the building, or that one of the principal pyramids at Nohpat lay in

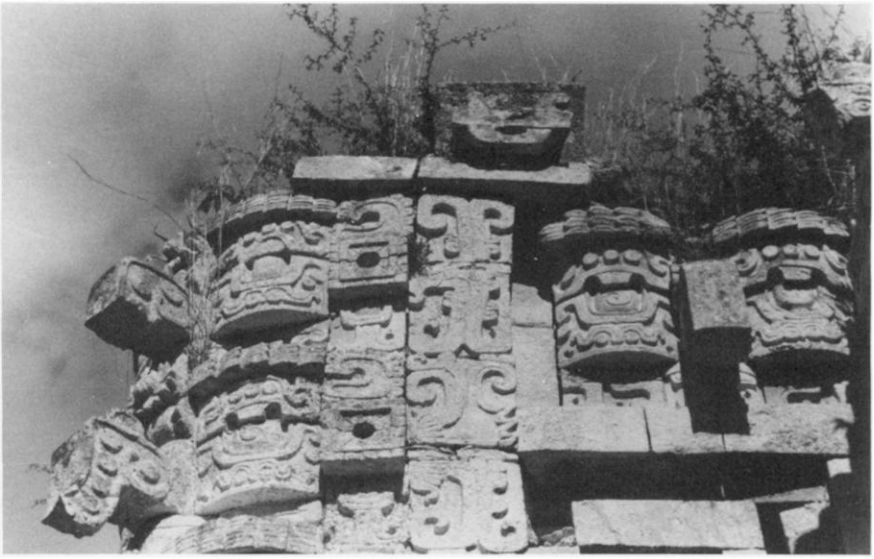

FIG. 6e. Uxmal: Palace of the Governor; Chac (Rain God) masks display the Venus glyph below the eye.

direct line with the doorway. At both Uxmal and Nohpat one finds altar platforms with practically identical reliefs (cf. Stephens 1843, 1: 221, 223). And a stela reported to have adorned the base of the principal pyramid at Nohpat (Stephens, 221) depicts a figure with a hand raised pointing to a

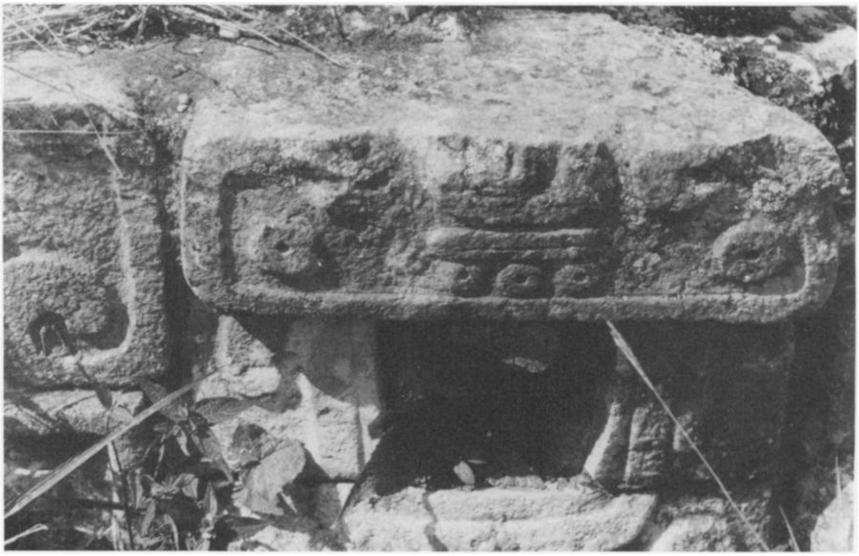

FIG. 6f. Uxmal: Palace of the Governor; Maya numeral 8 over the eye of Chac.

star-like image over it. Unfortunately, we were unable to locate these items on recent visits to Nohpat, a site which is thoroughly overgrown and, we suspect, heavily looted.

The Venus orientation makes sense as an empirical derivative source for the material appearing in the Maya written calendar. Thus, it has become clear from studies of the Venus Table in the Dresden Codex, which was written in the Yucatan, that Maya astronomers would have needed to make especially careful observations of Venus at the rather critical period of disappearance, as well as about the standstill, in order to have composed the Venus text of Dresden p. 24, 46–50. For example, Venus reaches the critical standstill position every eight years or five Venus cycles, the length of a single traverse through the table. Consequently, we should not be surprised to find the embodiment of the precise direction of these observations framed within the sacred architecture of a Maya city and in this instance, registered by an alignment between buildings in two ceremonial centers which were intimately related. They were, in fact, connected by a causeway that departed Uxmal from the region of the Palace of the Governor.

The Nunnery (fig. 5a, [A]) is another Uxmal structure that deviates from the basic orientation, but in a more complicated way. It is quadrangular in shape, all of its sides differing in length and by varying amounts from orthogonality. At first glance, the whole plan seems random (fig. 7). The eastern side, which lies closest to the Pyramid of the Magician, with which it may have possessed some physical connections, is out of line by only 2° from the general site axis. The northern structure also is misaligned by 2°, and the southern structure by only 1°, but the western structure deviates by 5°. As Aveni and Hartung (1982b, 71–75) have suggested, internal construction principles of a highly ordered nature may have played a role in distorting the appearance of this building complex. We considered the following sets of axes (see fig. 7): (a) that formed by a pair of lines, one connecting the central doorways of the east and west structures, the other the central doorway of the south structure (the Archway) and *that doorway adjacent on the west to the central doorway of the north structure* (solid axes); and (b) that formed by another pair of lines, one connecting the central doorway of the eastern structure with *that doorway adjacent on the north to the central doorway of the western structure* (dotted axes). We found both sets of axes to intersect almost precisely at right angles near the center of the enclosed patio. That the Maya might have chosen to construct alignments among doorways of the Nunnery is supported by the following numerical oddities: Each structure that opens on the unit contains an odd number of doorways—five on the east, seven on the west, nine on the south, and eleven on the north. Moreover, the last of these apertures looks southward over the archway toward the east-facing Palace of the Governor, a building that possesses thirteen doorways (and twenty rooms). The view from the center of the courtyard through the center of the archway neatly frames this magnificent building. A further indication of order in the plan

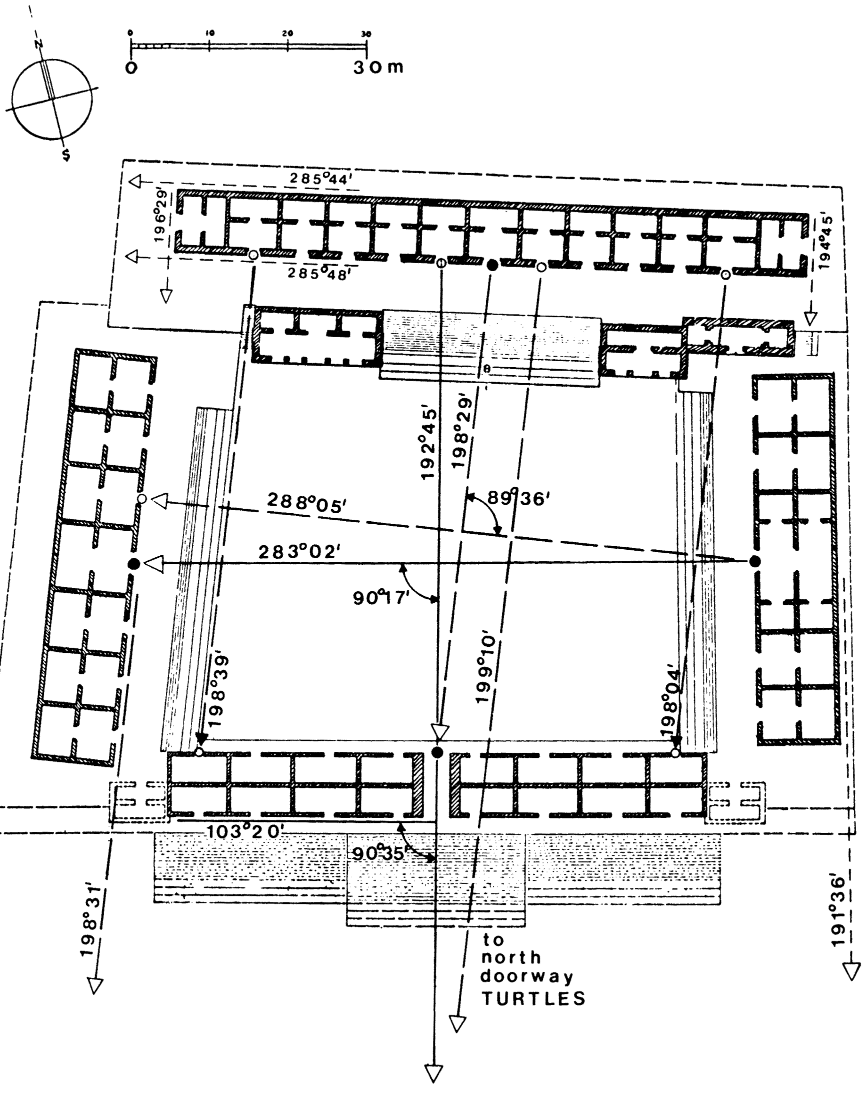

FIG. 7. Plan of the Nunnery of Uxmal showing alignments indicating geometrical relationships.

can be seen in the west building, which is parallel to the north-south arm of the first set of axes, and in the south building, which aligns with the east-west arm of the same set. Finally, lines connecting the end doorways of the north and south buildings are parallel not only to each other, but also to the north-south axis of the first set (the precise alignments are given in fig. 7).

What is the significance of the discovery of precise geometrical relationships among the buildings that comprise the Nunnery at Uxmal? At this stage, we can only conclude that some sort of special considerations must have existed in the minds of the builders of this great city. But to determine precisely the principle or set of principles, we must have access to data concerning the construction sequence of the Nunnery complex. Since such information is sadly lacking, it would be unwise to speculate beyond the conclusion that skewed alignments and disorientation, at least in two buildings at Uxmal, were not due to sloppy construction, but rather were deliberate and may have been a part of a more elaborate, orderly plan that escapes our understanding at present.

How can one account for the only other building at Uxmal that deviates noticeably from the prevailing axis? The Pyramid of the Magician (fig. 5a [B] and fig. 8) is skewed 9°17′ rather than the usual 13° clockwise. Its present outer structures (Phases IV and V) are the only ones that can be measured with any reliable precision and they fit the overall axial grid closely. The facing directions, 99°17′ on the east and 279°17′ on the west, offer a magnificent elevated view of sunrises and sunsets over a flat (0° elevation) horizon. While the dates of sunrise corresponding to these directions appear to have no significance known to us, the sunset dates may have been important. The dates matching the sunset direction are 12 April and 31 August, and there is an important phenomenon in the calendar that may have been connected with these dates. The passages of the sun across the zenith occur almost precisely three uinals apart, on 22 May and 22 July, in the latitude of Uxmal. We shall develop the zenith-sun orientation calendar hypothesis more fully in a later section of this work. It also may

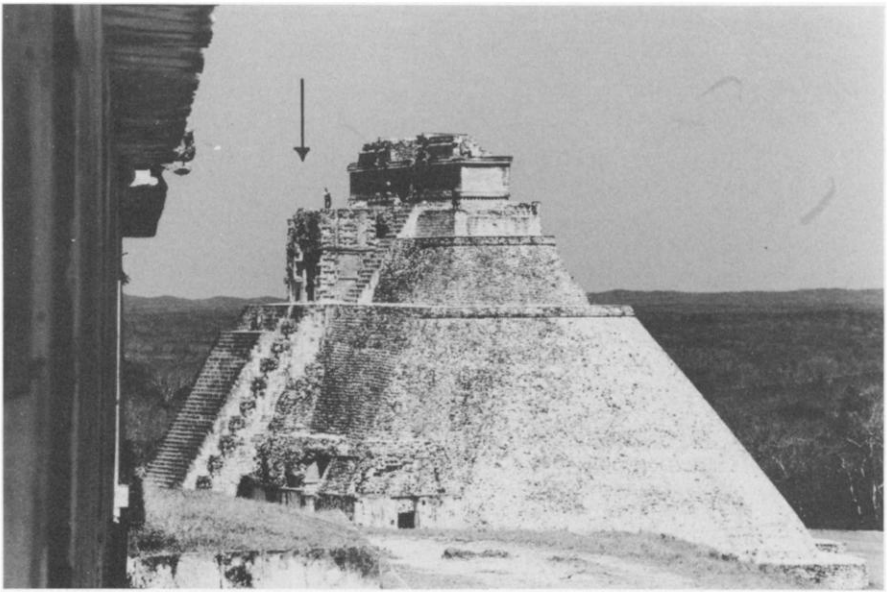

FIG. 8. Uxmal: Pyramid of the Magician; view of the western facade from the Palace of the Governor (arrow marks Chenes-style facade).

be significant that these dates are separated by two lunar synodic months. Thus, *the phase of the moon will be the same on the night of the day when the sun crosses the zenith at noon upon its return to the south as when it crosses the zenith and passes into the northern part of the sky.*

The 9°17′ west of north skewed alignment embodied in the Pyramid of the Magician at Uxmal may have been part of a convenient empirical orientation calendar that divided up the solar year in a way that employed both direct observations of the sun at horizon which fit precisely with the base-twenty counting procedure the Maya had developed for keeping their written calendar. One merely needed to observe the 12 April sunset in the western doorway of the Chenes-style temple of the Pyramid of the Magician (arrow in fig. 8), then count two twenty-day periods to arrive at the solar zenithal passage. Exactly three uinals later the sun would pass the zenith a second time. Two uinals after the second zenithal event, the setting sun would return again to the doorway—this time coming from the opposite direction. These orientations provide a calendrical framework for the most significant portion of the agricultural year, a period of seven uinals running from the end of the dry season almost to harvesting. (See Aveni 1977 for a similar argument concerning the alignments at Copan.) The detailed ethnohistoric and ethnographic justification for the hypothesis of a calendar pivoted about solar zenith passages is given in the conclusion here.

Now, if this is true, we can ask: Is the date of the first solar zenith passage plus or minus one uinal also evident in the alignments at Uxmal?—i.e., ought we not expect that if the Maya calendar keepers registered a solar station at *two* uinals before zenith passage, they also would have a similar point at *one* uinal before this time? The orientation to look for would be about 16°N of W in the latitude of Uxmal. While no buildings at Uxmal possess this direction precisely, the longitudinal axes of three apparently unrelated structures do offer a close match: the North Building of the Nunnery, the north facade of the Pyramid of the Cemetery Group, and the Great Pyramid (see listing in Table 1).

We should inquire further as to the positions of sunrise and set on the days of passage across the zenith at Uxmal to see whether these orientations also appear as alignments in the architecture. The *sunset* azimuth, 291°58′, is closely matched by the orientation of another slightly deviant major building at Uxmal. The Lower Temple of the House of the Old Woman at the southeastern end of the principal zone looks toward the western horizon, aligning at 292½° azimuth. Unfortunately, the level of tolerance of our measurements on the badly fallen facade is 1½°. This line of sight passes over the terraces of the elevated South Temple which, at a range of nearly four hundred meters, rises about 2° above the western horizon, enough to dismiss any worries about whether the latter building would have blocked the view. All these alignments lie within the limit of the naked eye for determining the zenith passage dates. They also lie within the bounds set by the ethnohistoric record referring to the accuracy with which the Maya marked these dates. Moreover, these determinations are consistent with the degree of accuracy with which the builders of Alta Vista (Chalchihuites) in northwestern Mexico laid out architectural elements to correspond to the solar zenithal passages at the Tropic of Cancer (Aveni et al. 1982).

To summarize, in Table 2 are the principal points in the hypothetical solar year reckoned from the first zenith passage at Uxmal, together with alignments in the architecture that may have been utilized to mark the significant points in the annual cycle. Finally, for the sake of completeness, we should point out that we have considered (cf. Aveni 1975, see esp. fig. 6; Hartung 1971) other possible astronomical alignments associated with the placement of the western upper doorways of the Pyramid of the Magician at Uxmal (see fig. 5a):

(1) A line to the doorway of the Lower Temple of the House of the Old Woman, 180°20′, is almost due astronomical south. A deliberate reason for this alignment now seems indicated by the information on the possible astronomical significance of this building.

(2) A line to the central doorway of the West Group, which also passes over the center of the Ballcourt and over the center of the courtyard on the northern side of the South Group bears 240°20′. This direction lies about 1° from the Venus set position at its extreme southern limit; i.e., Venus sets along this axis on the days when it rises in the doorway of the Palace of the Governor.

(3) The alignment over the center of the patio of the Nunnery (defined by the crossing points discussed above (Aveni and Hartung 1982b, 71–75) points to within a degree of sunset on the summer solstice. It also passes roughly through the center of the Platform of the Stelae.

SAYIL (figs. 5b, 10)

Sayil (map, fig. 5b) is located in a valley bordered on the north and west by rather steep hills. Some of the buildings are on low natural rises while others are on the tops of the hills. Thus, local topography appears to have influenced building orientation at this site, at least in part. The hills bordering the site on the western side generally run in a NNE-SSW direction, which corresponds to the alignment of most of the buildings in that sector. Pollock (1980, 85) noted the north-south axis, indicated in the form of a sacbe or causeway, as the principal feature of the civic plan. A prolongation of this axis to the south passes within five meters, at a distance of one kilometer, of the center of the Ballcourt, as one will note on the map. In a similar way, the extension of Sacbe No. 5 at Chichen Itza points to the center of the Ballcourt in the southwestern corner of the Group of the Thousand Columns (Hartung 1971, plan 7). The centers of ballcourts, often indicated by markers, have been postulated to represent decisive points in the planning of Maya centers such as Piedras Negras, Yaxchilan, Chichen Itza, and Uxmal (Hartung 1971).

As at Uxmal, the buildings at the north end of this axis generally face toward the south, though the converse is not true. Based on measurements taken at the base of its stairway, we determined that the facade of the Great Palace (the largest structure pictured at the north end of the map) faces 12°23′W of S (azimuth 192°23′), or about the same as the north-south axis of Uxmal. (The eastern and western segments of the southern facade are folded backward from the central axis to face 183°17′ and 198°52′, respectively.) Tucked into the northwest corner of the valley, the Great Palace of Sayil overlooks the northern terminus of the great causeway, which begins at its base and runs precisely astronomical north-south for three hundred and fifty meters until it enters two interconnected courts (see Group of 3B2 on map). The structures of the North Group of Sayil (not shown on our adaptation of Pollock's map), located on a hilltop at the extreme northern end of the site, about five hundred meters north of the Great Palace, look almost directly down this portion of the causeway and face southward toward the other major groups.

The Group of 3B2, at the middle of the site, consists of an irregularly shaped but generally quadrangular assemblage of four buildings (aligned 187°–193°) that surround an open court, the whole complex being reminiscent of the Nunnery at Uxmal which also is located at about the middle of the north-south axis of that site. Departing this complex, the causeway proceeds in straight but slightly deviated linked segments 250° toward the south-southeast, passing another group of inward-facing buildings (Group of 3C2; alignment 191°–197°). From this point, five short, angled sections lead three hundred and fifty meters to the largest complex at the site and the center of the zone of heaviest concentration of outliers.

This southern group (Group of 4B2) contains the Ballcourt (4B3), the axis of which aligns 106°–286°. The first structure approached by the causeway, it adjoins several multichambered buildings, the two most prominent of which face one another along the same generally NNE-SSW axis.

The Ballcourt at Sayil is the only major structure at the entire site that opens in the east-west direction and therefore is the only one that might conceivably possess some direct astronomical significance in the sense that the alignment could be employed to register a visible solar position. The extension of its axis, shown at the bottom of fig. 5b, faces sunrise (over a ½° elevated horizon) on 1 May and 13 August. These dates are separated from the solar zenith passage dates by a little over one uinal. Thus:

1 May	sunrise down east-west axis of Ballcourt (+21 days =)
22 May	first zenith passage (+61 days, approximately three uinals =)
22 July	second zenith passage (+22 days =)
13 August	sunrise down east-west axis of Ballcourt.

The view to the east, over a similarly elevated horizon, marks sunrises on 9 February and 3 November, for which we find no particular significance. Therefore, we can say that the only building at Sayil that physically faces

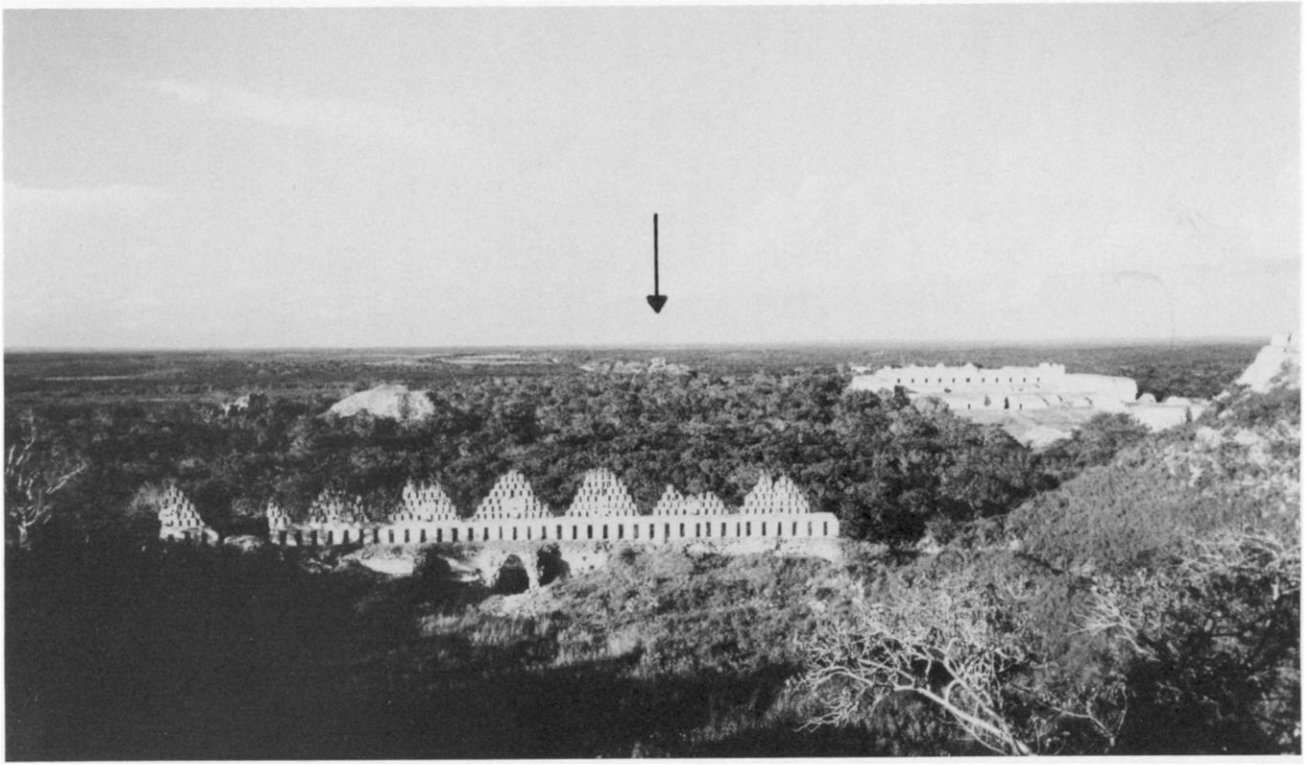

FIG. 9a. Uxmal: View along the principal axis of alignments from the South Group to the North Group (H to M in fig. 5a). Arrow points to North Group.

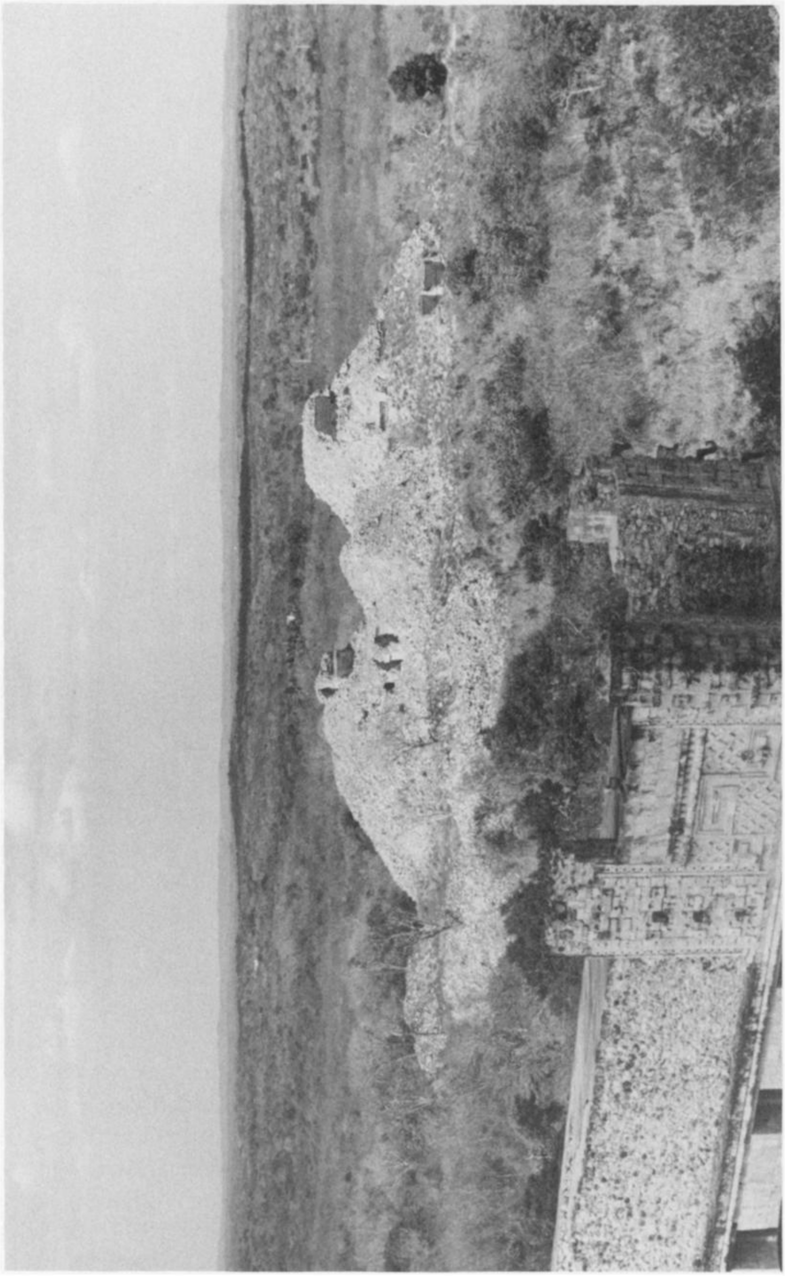

FIG. 9b. Uxmal: The North Group as viewed from the Chenes Temple of the Pyramid of the Magician.

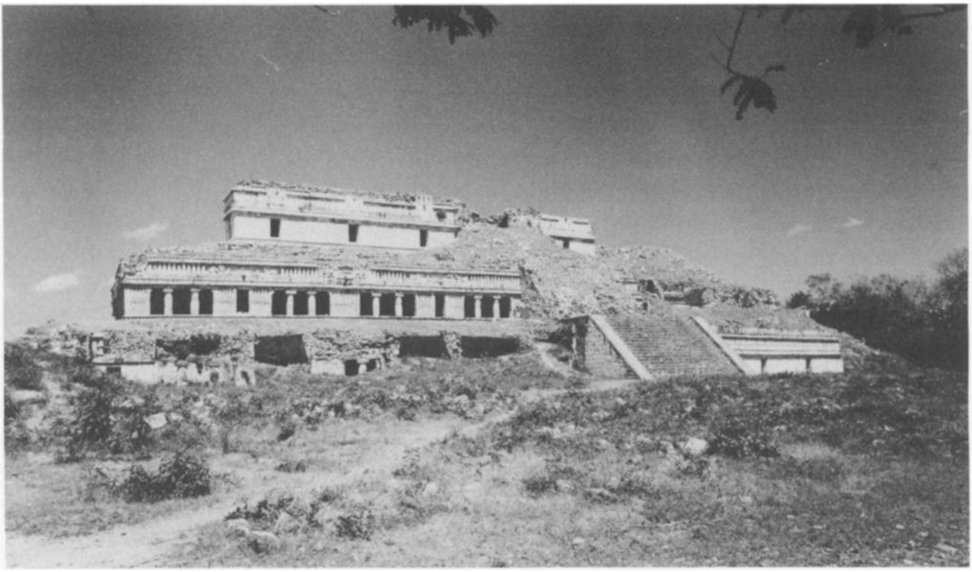

FIG. 10. Sayil: Great Palace, south facade.

the zone through which the sun moves on its annual course does, indeed, possess an orientation that is consistent with a sun-watching scheme based upon counting uinal-length intervals surrounding solar zenith passages.

If we compare the distribution of the alignments of the principal buildings at Sayil with those at Uxmal, we find remarkable agreement between the two data sets. The agreement is enhanced if we regard the Palace of the Governor as a special case and remove it from consideration. The alignments (folded about true north) of three-quarters of the Uxmal buildings are situated between 9° and 15° clockwise from the north, while ten of the twelve major Sayil structures fall in the 7°-17° zone. Also in contrast to Uxmal, at Sayil none of the structures deviates radically from the prevailing alignment.

Given that the alignments at the two sites are practically the same, we are tempted to conclude that the "Puuc orientation habit" passed from one site to the other. Possibly, the principal alignments at Sayil were adopted from Uxmal. But how? These directions could have been transferred only by using as horizon reference points celestial objects, which would be observed to rise and set in essentially the same absolute direction in space at the two cities. (The latitude of Sayil differs from that of Uxmal by only eleven minutes of arc.) Therefore, if identical astronomical phenomena at the horizon were employed to lay out common directions at the two sites, we would expect, under the most ideal conditions (i.e., identical, unobstructed horizons), that the structural alignments would deviate linearly by no more than thirty centimeters over a distance of a hundred meters.

KABAH (figs. 5c, 11, 12)

Like Sayil and Labna (see below), Kabah (map, fig. 5c) also is divided by a causeway. Though this visible remnant of the north-south axis is now destroyed, we were able to secure a measurement from the top of the principal pyramid (1B2) at the north end of the site to a lesser one (3B1) that defines the south end, these two structures once having been joined by the causeway. The result, 189°41′, indicates that the south-north bearing of the causeway (as read from the map) passing from the southernmost structure to the central grouping would have been about 5°E of N, the wider, shorter segment leading to Structure 1B2 at the north end, bearing approximately 18°E of N. In contrast to its neighboring sites, and perhaps more like Uxmal, Kabah has large complexes of buildings on either side of the axis; in fact, Pollock (1980, 140) has suggested that a prominent east-west axis also is recognizable, with the eastern and western buildings, like those on the north and south, looking toward each other. While the main structures generally were built on flat terrain, those in the northwestern section are perched on elevated rock outcrops.

Let us turn next to the alignments of individual structures. Our list for this site reveals that, as at Uxmal and Sayil, the axes of most of the buildings are confined almost exactly to the same span of orientations. Seven structures are tightly grouped in the 10°–18°E of N region with two others falling at 5° and 2°E of N. Dominated by a magnificent arch (1B1; fig. 12),

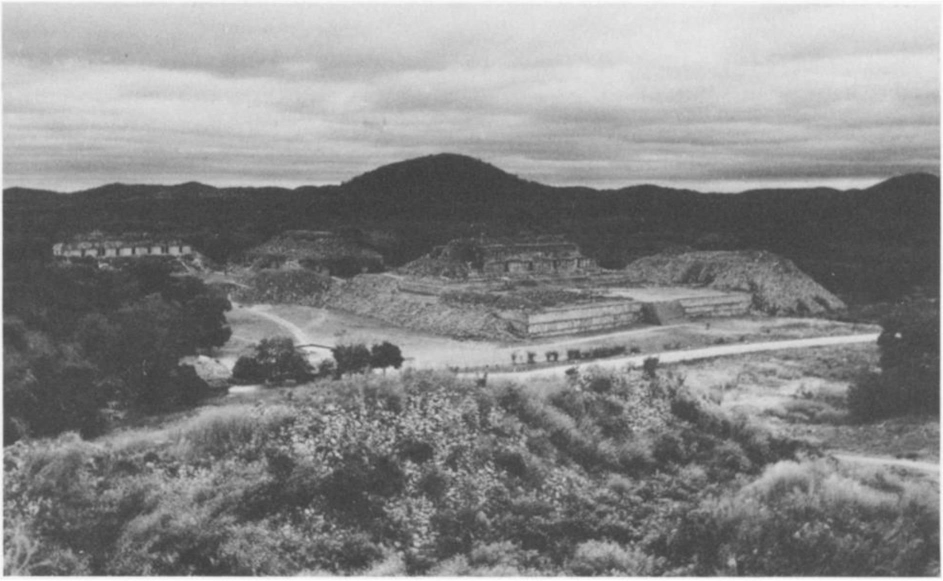

FIG. 11. Kabah: General view.

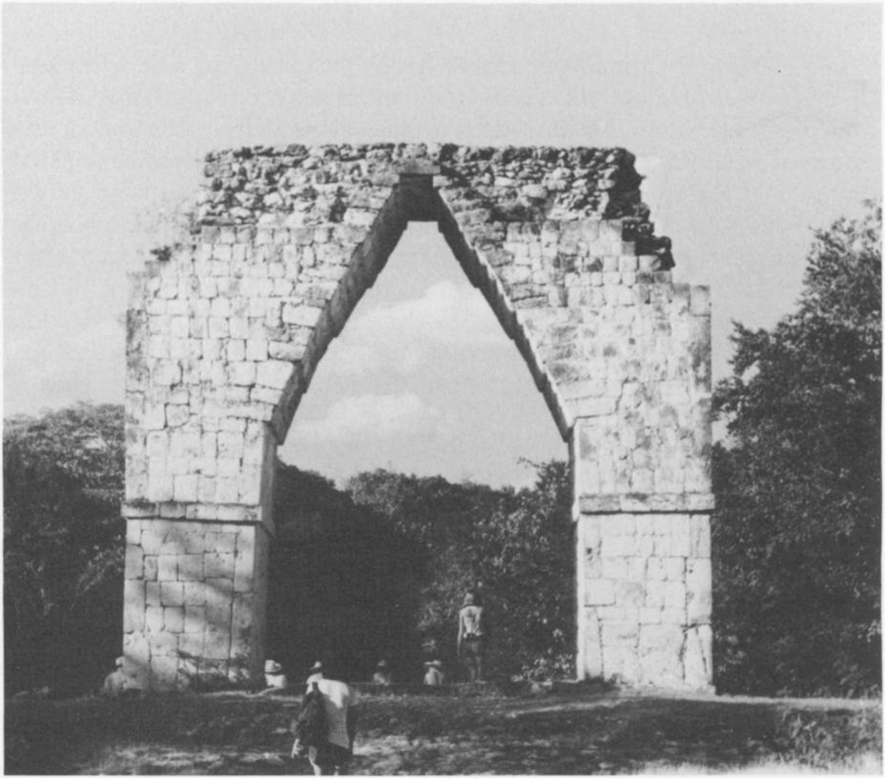

FIG. 12. Colossal Arch at Kabah. The sacbe that begins there leads to Uxmal.

the causeway from Kabah to Uxmal departs the site in the direction 347° from the western flank of the complex at the southern end of square 1B of the map, one of the rare examples of a west of north alignment. From Kabah, Uxmal actually bears 330°, but the causeway turns slightly once it leaves the site. It is likely that this unusual orientation was dictated by an exterior factor, namely the location of Uxmal.

The western buildings, including Los Dinteles (1A1) and Las Grecas (1A2), look eastward toward and over the Great Pyramid Complex (1B2), in directions 104°–108°. Thus, the average alignment of the three is the same as that of the Sayil Ballcourt. At Kabah, however, local topography may have been a controlling factor. The ridge on which these structures were built also is aligned in the NNE-SSW direction (about 15°–195°).

Like the Great Palace at Sayil, the principal pyramid (1B2) at Kabah not only lies at the northern end of a causeway aligned almost precisely north-south, but also the building is skewed clockwise out of line from the direction of the causeway by 9° (cf. 12½° for the Great Palace).

Other buildings on the east end of the site (zone 2C) align 12°–16°N of W. Four of these enclose a court while the largest building, which is located at the east end of this complex, overlooks the aforementioned buildings in the northwest section. Only 3B1 at the center of the site exhibits any marked deviation from the plan. Aligned 5°E of N, it looks generally up the causeway toward the principal pyramid. As at Sayil, one has the distinct impression that at Kabah, the architecture is strictly inward looking. Just as the structures of Group 3B2 focus on each other, so too do the four principal groups of buildings seem to focus attention on an area one to two hundred meters south of the principal pyramid. Yet, we must remember that the same absolute general set of alignments one finds at Uxmal and Sayil is clearly in evidence at Kabah.

LABNA AND OUTLIERS (figs. 5d, 13)

Though Labna is a much smaller site than Uxmal and Sayil, it shares a number of basic structural characteristics with its neighbors to the northwest: (1) it is located on a valley floor flanked by low hills; and (2) the civic plan is dominated by a north-south axis marked by the causeway (aligned 358°) that connects two major building complexes that lie at its poles. (See figure 5d for details.) The large spread in the alignments of the buildings noted by Pollock (1980, 10) is, however, evident in our listing, in marked contrast to the more regular arrangement at the major Puuc sites. The alignments of the generally southeastward-facing buildings at the north end of the center have a 10° variation about 21°W of S, while the arrangement of buildings at the south end of the axis can be characterized only as multi-directional. The tallest structure at the site (Str. 4), appropriately called the Mirador (or "lookout"), towers above all the others. Part of the southern complex, it is turned away from the Palace Group and faces 12°02'W of S (within ⅓° of the alignment of the Great Palace at Sayil). Its facade also is directed toward the South Group of buildings and Stela 1, which are situated on a hillside several hundred meters away. In effect, the excavated portion of Labna may represent only that segment of the site that resembles the northern half of neighboring Sayil (cf. fig. 5d and top half of fig. 5b).

Chuncatzim, an outlier one and a half kilometers to the north, may well be considered a part of Labna, though Pollock (1980, 53) regards it as a "small, isolated civic and religious center serving the little valley it overlooks from its hilltop location." We measured the only structure extant at the site and found it to align 25°00'E of N. Sabbache, one and a half kilometers north of Chuncatzim, consists of several small complexes on the crest of a low ridge running north-south and overlooking other buildings scattered on the valley floor below. These are skewed 12°–25° clockwise. We also measured the only standing structure at Xlabpak, which is located in generally flat terrain five kilometers southwest of Sabbache and three kilometers west of Labna (three kilometers southeast of Sayil). It is aligned 15°–195° and possesses doorways opening on all four sides.

OXKINTOK AND OUTLIERS (fig. 5e)

This site may have been among the largest in the Puuc region (map, fig. 5e). Sadly, it is in a rather advanced state of decay and has been given

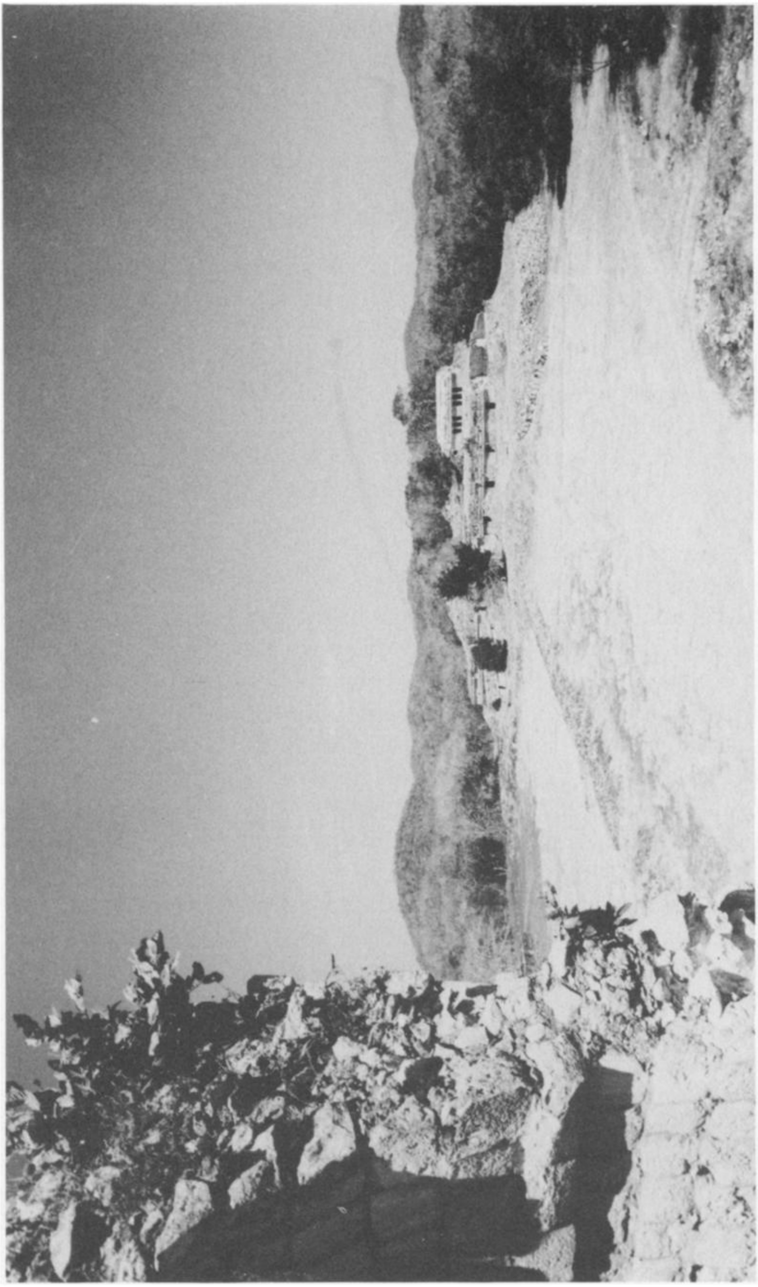

FIG. 13. Ruins of Labna: View from the Mirador over the sacbe to the North Group.

little attention by archaeologists. It is located at the extreme northwestern corner of the Puuc zone, thirty kilometers north-northwest of Uxmal in the acute angle between the eastern and western Puuc ranges. As at so many Puuc sites, there is no known permanent water source.

The principal axis of the site is defined by a line connecting the North and South Groups, which face one another. We were able to secure a measurement by situating the transit at the top of Structure 2 of the North Group (1B2) and sighting Structure 6 of the South Group (3B6), each being the tallest structure in its complex. This yielded an alignment of 190°16′ (astronomical); therefore, the south-north axis is skewed 10°16′E of N. From the bearings taken on several other structures, now mostly grass-covered mounds, we were able to pronounce Pollock's map quite accurate, particularly with regard to the placement of the north-south grid. Though we could not trace out at ground level the sacbe connecting the North Plaza to the North Group, which appears to delineate the principal axis over the northern half of the site, we did determine its orientation from Pollock's map to be 11°45′, which is very close to the visual north-south axis. Most of the individual buildings are arranged in plaza groupings and have clockwise alignments that range from 9°–13½°E of N. Causeways depart to the east and west of the North Plaza; the longest of these bears 115° and leads to another complex of unmapped buildings at a range of about one kilometer.

While Oxkintok is rather remote from the central Puuc zone and somewhat less well explored, the Puuc skew that our measurements have begun to establish as quite typical is still clearly evident in this plan. In Table 1, we note that the structures at Oxkintok and the neighboring sites all fall in the 9°–14°E of N region. This remarkable consistency of direction over an extensive area that is thoroughly punctuated by rolling hills leaves little doubt that a widespread orientation plan must have existed at least during the Terminal Classical Period.

Regarding possible astronomical orientations, we can do little with the Oxkintok alignments, except to do what we did at Uxmal, where we examined the eastward and westward alignments of buildings flanking the main north-south axis of the site. At Uxmal we were able to find some possible orientation significance in the westward-looking elevated facade of the Pyramid of the Magician, but the poor condition of the ruins of Oxkintok make identification of another such building unlikely. Based upon the plan, however, we can say that if one of the many cone-shaped rubble piles remaining there had been intended to look toward the horizon across the site axis, it would have faced sunsets at azimuth 280°30′ (or sunrises at 100°30′), approximately. In the latitude of Oxkintok (20°34′N), solar zenith passages occurred on 24 May and 21 July. The sun would have set along the 280°30′ direction on 13 April and again on 31 August (two uinals, two days before and two uinals, one day after the nearest zenith passages). The sunrise directions are somewhat less revealing. Therefore, Oxkintok at least holds the same potential as Uxmal for an orientation calendar based upon a double uinal count pivoted about zenith passage.

CHACMULTUN (figs. 5f, 14, 15)

Chacmultun, at the eastern end of the Puuc zone, is an excellent example of a site that may have been selected because its topography could be utilized in the realization of an architectural plan. As our map (fig. 5f) suggests, the buildings provide reasonable outlooks upon one another. At first sight, one has the impression that the utilization of the landscape in urban planning was very important here and astronomical considerations may have played no role. Yet, as the alignments in Table 1 show, the site still manages to retain some elements of the east of north skew, with buildings falling in the range 7°–20° clockwise. We wonder whether the builders might have found it necessary to seek out a location in the rather hilly landscape in which it would be possible to include the Puuc skew.

As one can see from the map (fig. 5f), all three complexes that comprise Chacmultun, the major one to the northwest and the two smaller ones on the southeast, are located on small hilltops. As Pollock has suggested (1980, 363), the buildings focus both upon one another as well as upon a point on the floor of the valley (which runs 50°–230°) that bisects the site. (We indicate the directions of the facades by dotted lines on our map.) The view from the Xeth Pool group to the large complex on the northwest is

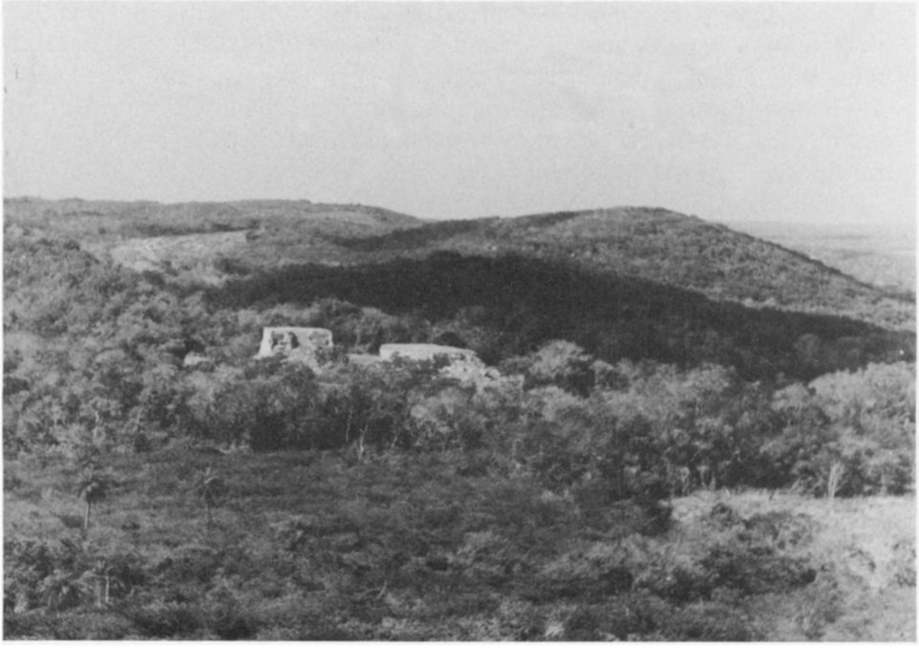

FIG. 14. Chacmultun: View from Xeth Pool to North Group.

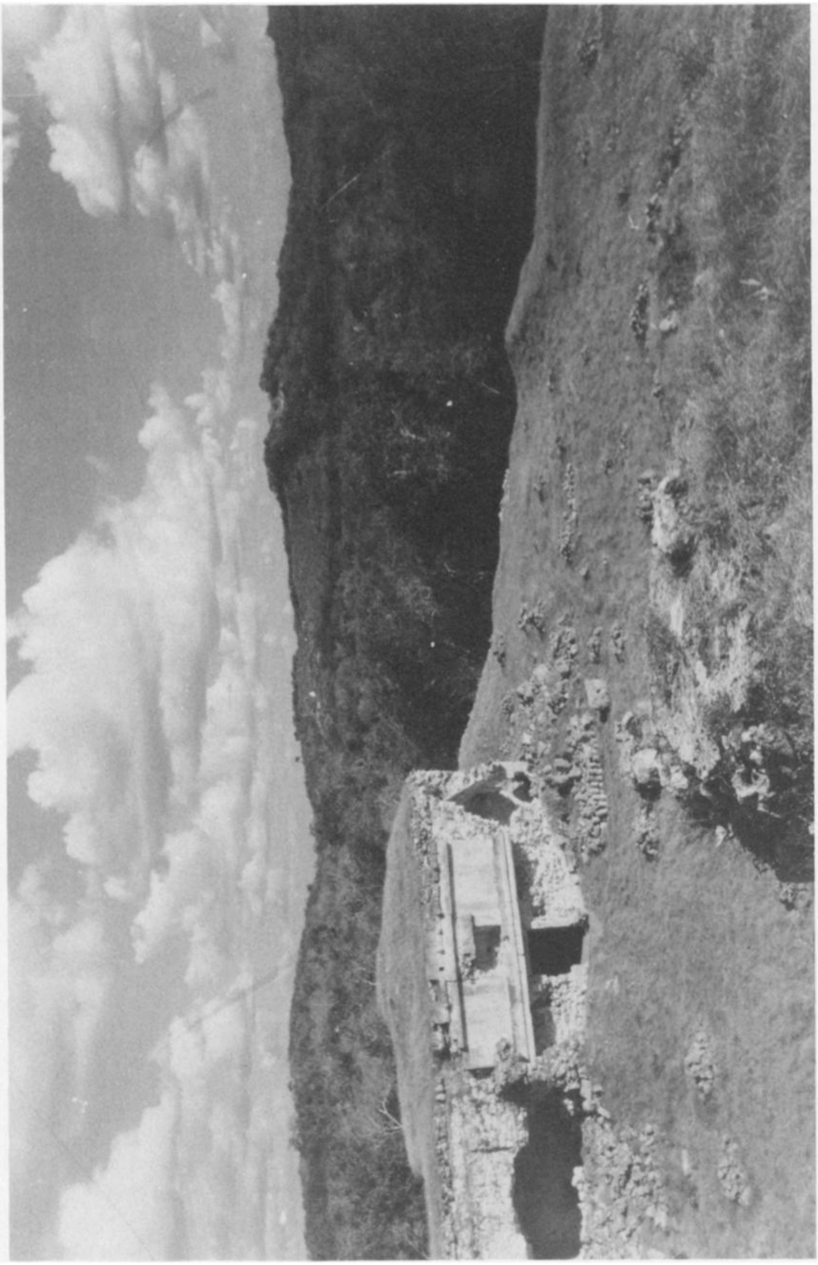

FIG. 15. Chacmultun: Str. A (foreground); Xeth Pool (background).

shown in figure 14, while the corresponding view in the reverse direction, taken from the doorway of Str. B, is in figure 15.

KIUIC

Located in the southwestern corner of G. Andrews's (n.d.) triangular region containing sites with Early Puuc architecture, Kiuic is on generally level terrain surrounded by low hills. Pollock admits that his map (1980, fig. 592), which shows several complexes of buildings with large spaces in between, is probably incomplete, which our visit in January 1984 to the rather heavily wooded site also indicated. At least the buildings appeared to be widely scattered. What we did measure, however, exhibits a rather tight adherence to the typical Puuc orientation plan. Building alignments in three complexes fall rather neatly in the range 10°49′–12°50′. Other sites in the immediate vicinity of Kiuic that we have included in the present study are Itzimte and Yaxche-Xlabpak which, as one can see from Table 1, also fit the plan, and Balche, which decidedly does not. Xkichmool (Xkichmook), located well to the southeast (and south of Chacmultun), has an 11°–18° spread.

XCALUMKIN, XCULOC AND THE PUUC SITES IN CAMPECHE

These sites lie in a high concentration of ruins about twenty square kilometers in extent, twenty kilometers west of Sayil across the present Campeche state border. It is perhaps inappropriate to include these sites in this study because they exhibit slight differences in Puuc style (Pollock 1980, 377) from those sites to the east discussed above. Still, it is interesting to see how far the adherence to the generalized Puuc skew can be traced.

At Xcalumkin, buildings appear to have been constructed on the tops and sides of hills above the savannahs. Our visit to the site in January 1986 confirmed Pollock's observation (1980, 420) that there was no discernible direction of approach nor principal axis of orientation. It should be noted, however, that the site is badly destroyed and heavily overgrown so that many of the buildings are extremely difficult to recognize. Local land contours appear to have played a major role in building orientation. The main group exhibits alignments spanning the range 4°W of N to 17°E of N. A transit measurement on one unidentified structure in this group yielded 12°27′E of N. In the so-called Hieroglyphic Group, alignments taken from Pollock's maps range from 7° to 16° (we measured a single building on the site at 5°34′). In the still more irregular North Hill Group, we measured a direction 124°42′ (34°42′ clockwise) on one structure.

Though no accurate map of the site exists, Xculoc is apparently the major site in the Campeche-Puuc region. Its ballcourt faces generally north-south and a large portal vault possesses the typical 12° alignment. We measured 9°51′ for the alignment of one structure which we were unable to find in

Pollock's publication. Measurements in the field taken at Chunhuhub, Xcochkax, Xpostanil, and Almuchil were added to these data, which were then employed to convert Pollock's maps of eleven other sites in the Puuc area of Campeche to true north. Likewise, we have added the alignment data for Pixoy and Tzum of von Euw (1977). It is difficult to know to what extent inaccurate measurements, the poor condition of the buildings, and the effect of grouping several different sites together contribute to the rather large azimuthal spread that appears. But even with these complicating factors, we find that the mean orientation for the Campeche group of Puuc sites is the familiar 12°.

THE QUESTION OF SITE CHRONOLOGY

We noted in our discussion of the histograms of figure 2a that with a significant corpus of alignment data one may follow orientation trends through time across Mesoamerica. Might this same strategy also be employed specifically for the Puuc sites?

In his studies of Early Puuc architectural style, G. Andrews (n.d. and 1985) examined his own and Shook's data on a number of specific structures at ten sites with pre-Florescent style architectural characteristics. Gendrop (1983,101–21,214–15), in a more general work on architectural chronology, also has attempted to isolate particular examples of the Early Puuc style. It is worth singling out the alignments of some of these buildings for separate study since they have been determined with fair certainty to be among the earliest constructed in an area now relatively crowded with sites. Thus, it may be possible to disclose when the peculiar orientation trend, which we have discussed at some length, might have had its start.

We plotted the data in Table 1 for the Early Classic Puuc style buildings separately (fig. 16). Comparing this plot with figure 2c we find a significant deviation between Early Puuc alignments and those of all Puuc sites considered together. The median alignment of Early Puuc (fig. 16) is several degrees to the right of that of all Puuc sites. The peak around 14° is discernible, and the hump around 24°, which is not so obvious in the general regional Puuc plot, is plainly visible in the Early Puuc sample. Looking at some of the individual cases, we find that the Early Puuc buildings in the northwestern part of Uxmal are noticeably deviated from the prevailing 13°E of N plan. Likewise, the buildings in the northernmost group at Sayil (not shown) are skewed considerably from the site plan, as is 3C, Structure 6 and its associated complex from the principal alignments at Oxkintok. At Kabah, the only two Early Puuc structures cited by Andrews also exhibit the largest deviations, 4° and 22° respectively, from the site mean (see map, fig. 5c). Such is also the case at Labna, where the five-room building (rooms 32–36) projecting southward from the Palace Complex, has four eastward-facing doorways pointing roughly toward the sunrise position at the December solstice.

At Balche and at Sabbache, the earliest buildings are the most extreme violators of the general east of north-skew rule that applies to the majority of Puuc alignments. We should point out that one of the alignments that agrees with the typical Puuc skew, Kiuic—Group 1, is also among those about which our chronology is the least certain. This is a rather large complex, which seems to have been built over quite extensively. Our only transit reading in Group 1 was taken on the facade of Str. 5, which offered

FIG.16 EARLY PUUC

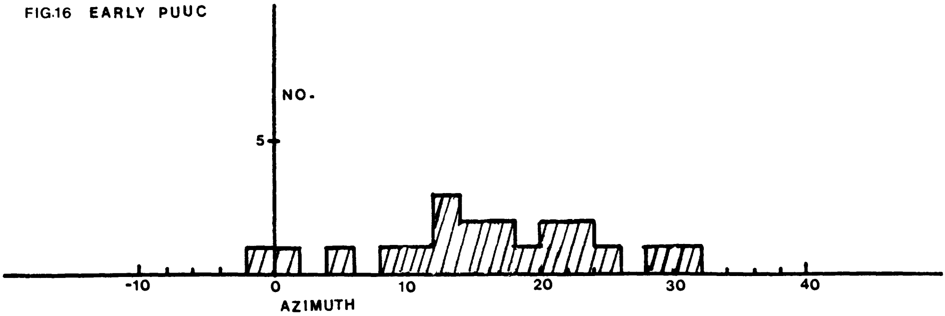

FIG. 16. Histogram showing site alignments for Early Puuc structures.

the only extant unreconstructed wall on which we could obtain an accurate measurement. It should be pointed out that Andrews's reference to Early Puuc style specifically applies to a room adjoining Str. 1–5 on the north, which may not have possessed the same alignment. Finally, since we have measured and surveyed the lowest extant original level of every building we investigated, we cannot be sure that an alignment we measured on a Florescent period building was not originally achieved by simply building on top of an Early Puuc structure that still remains to be excavated.

All things considered, it is possible to conclude that while the Early Puuc structures also have the general east of north bias common to their Puuc Florescent counterparts, they show an appreciably wider distribution about that mean; we take this to imply that architectural plans during the early period were less focused upon a rigid orientation principle. This result is consistent with the hypothesis that later builders who elaborated the Florescent style had either developed or imported a rather specific set of rules (undoubtedly with accompanying rituals) for aligning buildings, and with that set of rules, a rather precise orientation calendar that had not existed previously in the region. In the later buildings, this set of rules evidently was followed rigidly over the entire Puuc zone, though in regions more remote from the Puuc hills that still exhibited the Puuc architectural influence, the rules were not so strongly enforced (cf. fig. 2g).

Was the elaboration of these strict rules undertaken as a measure of control and did a general and detailed calendar reform accompany it? We shall have more to say about the consistency of alignment data with the established architectural chronology and with Maya historical chronology in general in the next section, wherein we explore some of the possible schemes for the evolution of the Maya calendar.

CALENDRICAL IMPLICATIONS OF ASTRONOMICAL ORIENTATION HYPOTHESES

What kind of astronomy became part of the theocratic and/or secular interest that was involved in the formation of the state and how did the developmental principles of the calendar derived from astronomical endeavors relate to the formation and expansion of the state? How did the highly articulated, precise calendar fashioned by the powerful priestly elite arise out of simpler symbolic systems? For the anthropologist, these are important questions, and archaeoastronomical studies are capable of suggesting some possible answers.

Throughout all Mesoamerica, from the Late Formative through the Post-Classic periods, the builders of the great ceremonial centers deliberately aligned their major buildings along axes deviating to the east of astronomical north, or clockwise looking down on the site maps. As we stated at the outset, this fact has long been appreciated in a general way (Macgowan 1945; Dursin n.d.; Aveni 1975), as well as on a regional basis (Aveni and Gibbs 1976; Pollock 1980). This study has served to increase, sharpen, and refine the data on this remarkable Pan-Mesoamerican trend and to examine possible causes for its origin and development. Our data consisted of more than two hundred alignments taken at ninety-six Maya sites which we have displayed in an azimuth distribution histogram (fig. 2a). In this plot, we entered one alignment per site, except in the cases in which particular complexes of buildings at a given site were found to possess markedly different alignments. The skewed distribution from true north is very obvious: 89 percent of the alignments fall to the east of north. Sharp maxima were found to occur at 14° (standard deviation 7°) and 24° (standard deviation 5°), the latter probably reflecting orientations to the sun at solstice. For the comparative sample of forty-three entries for twenty-seven sites in the Central Mexican highlands (fig. 2b), the east of north skew and the solstitial orientations are just as marked but the pronounced 14° peak is not so obvious. While both these diagrams exhibit the general skew, they are quite different in detail. When examined more carefully, they can be interpreted to imply that the Maya in general must have adhered to some sort of orientation principle that was, at a specific level, quite different from that which had been practiced in Central Mexico.

We focused our study of building alignments on the Puuc zone of northwest Yucatan because in this area there is a large number of sites concentrated in a relatively small space as well as in a fairly narrow chronological period (the Terminal Classic). This strategy aided us in approaching one of our goals, which was to attempt to assess the multitude of factors (not simply astronomical reasons) that might have led to the placement and orientation of ceremonial architecture. In the Puuc zone we studied the problem on a site-by-site basis. Another advantage of this strategy is that detailed studies pertaining to the general planning of ceremonial centers have already been made in the Puuc zone (Kurjack et al. 1977).

Having singled out the alignments of Terminal Classic sites in the Puuc region (fig. 2c), we found that, quite like the pan-Maya alignments, the directions averaged close to 14°E of N. In this case, the data sample of forty-four entries came from thirty-three sites. We noted that the Puuc histogram is essentially a reduced, sharpened version of the pan-Maya histogram (fig. 2a), with the 24° tail clipped off. We concluded that, whatever the cause, the 14° orientation principle (but not the solstice habit) was practiced during the Terminal Classic. Evidently, this was not the case at any other time in Yucatan, as the plots of figures 2d, e, and f for other chronological periods in Maya history in general demonstrate. Yet, the general east of north skew seems to have been a guiding principle for the nearly two millennia spanning the Early Formative to Late Post-Classic periods. For the marginally significant sample of Late Formative and Early Classic Maya sites (fig. 2d), we can conclude that perhaps some of the buildings had been intended to register the solstice. When we single out the Early Classic buildings in the Puuc zone (fig. 16), we reinforce the notion of the adaptation of a new set of principles in the matter of orientation. Once again, prior to the Terminal Classic, a higher percentage of buildings were oriented to the solstice and a smaller percentage adhered to the 14° trend. The Late Classic data (fig. 2e, fifty-two entries for thirty-two sites) yield about the same mean as the Puuc material, but the pronounced maximum at 14° is replaced by a rather broad 0°–20° distribution; the 24° bump still is present.

In the Post-Classic (fig. 2f), only the 15°–20° shallow peak is retained. This plot, derived from data obtained at sixteen sites from twenty-four buildings, bears a distinct resemblance to the Central Mexican histogram (fig. 2b). Thus, the Post-Classic exchange of ideas and goods that took place between Central Mexico and the Maya region also may have been accompanied by ideas pertaining to architectural and iconographic style as well as calendars and the planning and orientation of buildings. (Particular Toltec-style buildings at Chichen Itza serve as examples [Aveni 1980, 238–39].) But by this time, the Puuc style was already a remnant of the recent past, the standing architecture preserving earlier orientation principles that either had been forgotten or had been altered forcibly by intruders.

Why do we find these particular alignments? What orientation principles were involved? What did they have to do with calendars? Clearly, something special and different was going on calendrically in the Puuc region during the Terminal Classic—perhaps some sort of calendrical reform. To investigate the calendrical implications of Terminal Classical orientations in northwestern Yucatan, we return to the plot of figure 2c and to the data of Table 1 that comprise it.

Studying the plans of individual sites, we learned that not only are the major complexes systematically aligned, they also are similarly arranged—a fact that also had been recognized, though not explored, by G. Andrews (1975, 286) and Pollock (1980, 562). Prominent clusters of structures are distributed in a uniform manner along generally north-south lines that often are delineated by causeways. Pyramid-temples at the ends of the long axis usually face one another. In some cases, an opposing east-west axis or a series of small causeways juts off the principal axis, connecting the main site with other major structures or complexes. With rare exceptions, the structures look inward toward the axis and they tend to focus on points at the middle of the site. In some cases, particularly in the smaller centers (e.g., Itzimte), the cone-karst topography that defines the Puuc region appears to have influenced building placement and orientation; e.g., buildings often are located on hilltops. At Chacmultun, the buildings are perched on three separate hills that overlook a valley between them. Yet even in these two extreme cases the east of north skew is still detectable. In fact, there is hardly a Puuc site in which one fails to find it.

To explain these sharply focused, cardinally deviated alignments all over the Puuc region, we were forced to turn to astronomical causes, for there is no conceivable way of establishing nearly identical absolute directions in space over so wide an area without employing celestial references.

Looking to astronomy, we rejected as ethnocentric the notion that these people possessed an interest in astronomical matters purely for the sake of knowledge. Rather, there is abundant evidence in the ethnohistoric and epigraphic literature that places Maya calendrical and astronomical knowledge in a meaningful cultural context, close to the center of a rather all-pervasive religious ideology. The almanacs in the Dresden Codex demonstrate that the Maya went to great lengths to develop their calendar for divinatory purposes, specifically for the formalization of ritual relating to agriculture. Some aspects of this written calendar, for example the Venus Table in the Dresden Codex, indicate an interest in precise knowledge of celestial events. The record also provides evidence concerning possible ways of marking the sowing and harvest dates, of establishing the times for rainfall, harvest, festivals, etc.; thus we might say that the written calendar was both astrological and "agrilogical." We can imagine enclaves of priests from the holy centers visiting the surrounding towns with their codices tucked under their arms, ready to prescribe a particular ritual for a given event in the agricultural cycle by consulting their secret documents. Consequently, we would expect that any dates we might extract from a hypothetical orientation calendar would have agricultural significance.

Ultimately, any written calendar must have an empirical basis. Therefore, if we wish to develop an astronomical orientation hypothesis to account for the observed alignments of Maya ceremonial centers, we should examine the structural principles associated with these written calendars. A reasonable, testable hypothesis might therefore be that in order to evolve and adapt ceremonial principles to the ecology of the region they inhabited, the Maya marked directions in the landscape corresponding to positions of the sun during the agriculturally significant portion of the annual cycle. Such an empirical, unwritten calendar could serve to promote public awareness of the orderly passage of time, a concept that could be supplemented and reinforced by the more secret and sacred information held by the priest-specialist and conveyed to the public through his interpretation of the written documents.

In her discussion of the incorporation of astronomical-calendrical information into Maya architecture as a form of "interelite communication," Sharp views great art as "a form of communication that brings together people who are otherwise separated by social, economic, and political barriers" (1978, 169). Originating at the elite level, the information is "reworked" and transferred to the lower levels of society, and serves to define a style that unites people of widely divergent backgrounds and capacities at an emotional level. The international style of painting that swept Europe during the Renaissance is a familiar example. In Yucatan, the abstract, esoteric knowledge of the noble elite expressed in the Dresden Codex could be shared with the commoner through the rudimentary calendars whose existence is indicated by both the orientation and the decoration of the monumental architecture. The desire of the nobility to share their knowledge with the masses may have resulted from the shift from a sacred to secular basis of society, which is believed to have begun sometime during the Late Classic (Sharp 1978, 169). Therefore, it may be particularly significant if our results indicate that the orientation calendars flourished during the Terminal Classic.

If the calendar were a factor in the alignment of Maya buildings, it is likely that there would have been not a single central orientation calendar, but rather many local ones. We know from the inscriptions that various cities employed their own separate schemes for keeping the lunar count (see Aveni 1980, chap. 4, for a discussion). Such behavior would be consistent with the generally perceived autonomous nature of the Puuc power centers. Also, there are drastic differences in rainfall, relative number of clear days, soil types, and general topography from the north shore of the Yucatan peninsula southward across the Puuc hill country through the Peten and into the highlands. Consequently, we have an abundance of good reasons to believe that the ancient Maya might have developed a variety of adaptive annual calendars.

What type of calendrical format can be hypothesized to fit the alignment data that also converges with the written data concerning calendrical practice? We have some specific information that suggests a starting point for the calendar. Often this was one of the solstices, but frequently it also was fixed with the time of passage of the sun across the zenith, or overhead position. This event occurs twice annually in the tropical latitudes, and nowhere else in the world (Aveni 1981c). Moreover, the time of occurrence of the event pair in the seasonal year varies with the latitude, thus promoting the notion of annual calendars with different starting points. Don Juan Pio Perez writes (Stephens 1843, 1:280):

> To this day the Indians call the years Jaab or Haab, and, while heathens, they commenced it on the 16th of July. It is worthy of notice that their progenitors, having sought to make it begin from the precise day on which the sun returns to the zenith of this peninsula on his way to the southern regions, but being destitute of instruments for their astronomical observations, and guided only by naked eye, erred only 48 hours in advance. That small difference proves that they endeavored to determine, with the utmost attainable correctness, the day on which the luminary passed the most culminating point of our sphere, and they were not ignorant of the use of the gnomon in the most tempestuous days of the rainy season.

He goes on to list the eighteen months of the Haab, beginning with 1 Pop = 16 July, each running twenty days in length. Undoubtedly, Pio Perez derived the first part of this statement from Bishop Landa (1940 [1566], 150), who stated: "The first day of the year with these people was always on the 16th day of our month of July and the first of their month of Pop." It has been pointed out (Bricker 1982, 102), however, that Landa's equation may have been relevant only for a four-year period during the sixteenth century, and therefore cannot be taken as proof in any sense that New Year's Day always corresponded to solar zenith passage.

Nonetheless, on 16 July (Old Style), 26 July (Gregorian), the sun was close to the zenith in Yucatan. Peto, where Perez's manuscript was composed, lies at latitude 20°08′N, about the same as the southern middle region of the Puuc zone (the area around Sayil, Kiuic, and Chacmultun). The sun crosses the zenith of this region about 22–23 July (and 22–23 May). On 26 July (and 19 May) it stands overhead in latitude 19°40′N, which runs just below the southerly extreme of the Puuc zone, approximately through Tabasqueño and Nohcacab. The mid-latitude of Puuc sites is ½° north of this line, which corresponds empirically to one-sun-disk-at-zenith-passage. This error is about the size quoted by Pio Perez.

The concept of utilizing the overhead crossing of a celestial body as a time marker has other Mesoamerican analogies. It is reminiscent of Sahagun's famous passage which indicates that in Central Mexico the Calendar Round began anew with the timing of the zenithal crossing of the Pleiades (Sahagun books 4 and 5, 1957 [1582], 143–44). Also, one is reminded of the functioning zenith tubes at Xochicalco and Monte Alban.

Evidence on a zenith-sun based calendar also is provided in the contemporary ethnographic record; for example, the Momostecans (a people of highland Guatemala) call the solar zenith passage the "change of roads," which function as temporal guideposts in the agricultural calendar (Tedlock n.d.). Another survival of the solar zenith calendar exists in the valley of Jocotan near Copan (latitude 15°N). There, the natives are said to mark the beginning of the social, religious, and economic year on 25 April (the day of St. Mark), which also is said to commence the rainy season (Wisdom

1940, 462). On this day, which we determine to have occurred about five days before the first crossing of the sun in the zenith of Copan, a great festival is held. It follows a several-month period of agricultural inactivity which includes little travel or social life. Eight days later, on 2 May, the festival, which consists primarily of prayers to God and the native deities to bring rain, comes to a close with the anticipation that on 3 May (the day of the Holy Cross and the first day of the planting festival) or shortly thereafter, rain will come. Planting follows immediately, and if rain already has come, which it usually does by the first week of May, sowing takes place on 4 May. Beginning with this festival, which neatly encompasses the solar zenith passage, Wisdom (1940, 462–71) outlines a complete eight-month sequence of activities up to early January, by which point the fields lie fallow and the community once again lies dormant.

But how would the pre-contact Maya have grouped the days in the planting cycle? Looking to the codices and monumental inscriptions, we find that one of the dominant structural principles in the annual solar calendar, the so-called *Haab,* was the division of time into twenty-day periods (*uinals*). Such a practice, undoubtedly derived from counting by digits, had led to the development of a vigesimal count for all quantities, including time intervals, the basic unit of which was the day (*kin*).

Given all the evidence, together with an inductive push derived from our examination of alignment data from individual Puuc sites, *let us adopt the reasonable assumption that the orientation calendar, which we offer as an explanation for the systematic axiality of ceremonial centers, pivoted about the passages of the sun in the zenith. Further, let us suppose that the calendar was organized to indicate these events by marking the rising/setting positions of the sun at twenty-day intervals leading up to (and possibly counting past) the first of the year thus defined.* For the moment, we conservatively adopt *both* solar zenith passages as possible New Year's dates, but in so doing, we should note in particular that the first zenith passage date (sun proceeding north) occurs shortly before the onset of the rainy season in many regions of the Yucatan peninsula, during a time of intense agricultural and social activity. Because the dates of the solar zenith passage vary with latitude, the adoption of the solar zenith passage as a starting point seems not only reasonable, but also it forces us to consider the collective properties of a set of distinct orientation calendars that apply to different latitudes.

If we postulate that such a solar horizon calendar lay behind the observed distribution of Maya building alignments, then it would be reasonable to perceive the east of north and west of south deviations as south of east and north of west skews, because the latter correspond to that region of the horizon through which the sun passes on its annual course. In northern hemisphere latitudes, sunrises appear south of due east roughly between 22 September and 21 December, while sunsets fall in the north of west zone between 20 March and 21 June. It is worth noting that while 90 percent of the Puuc alignments are skewed clockwise from the cardinal points, *90 percent of these lie in the 0°–26° range,* the upper limit of which corresponds to the maximum annual deviation of the sun from an east-west line (i.e., the solstice). If the azimuth distribution had been purely random, then one would expect only 60 percent of the alignments to fall in this region.

The alignment data support the general existence of pan-Maya horizon calendars based upon the solar zenith passage dates, as we can see in figure 17. There, we plot the azimuths of building alignments as a function of latitude for all the Maya buildings we have measured. Except for a few scattered points, these data are enveloped by a curve (solid line) that runs very close to the positions of the sun at horizon calculated for the days it transits the zenith (dotted line). The envelope curve, sketched to fit the data, deviates from the computed zenith-sun limit only as one approaches the higher Yucatecan latitudes.

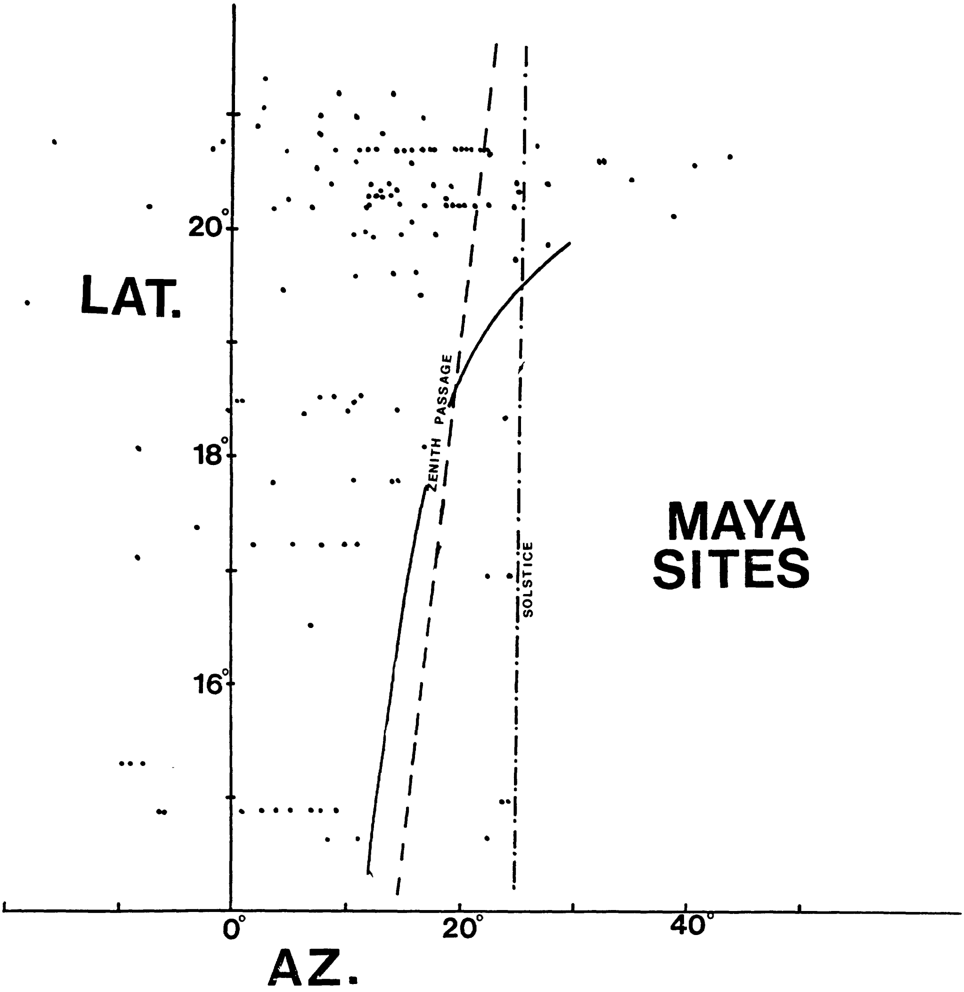

FIG. 17. Graph showing site alignments as a function of latitude in Yucatan.

On purely calendrical grounds, there is no reason to anticipate such a scatter in the extreme north for we know the Maya throughout Yucatan adhered to a precise calendar throughout their history. The *tun-ahau* dates from northern Yucatan are at least as precise as Peten-Style Initial Series dates and they were still in use when the Spaniards arrived in Yucatan (Bricker 1982, and personal communication). But the alignment histogram for the Post-Classic sites reflects a relatively weaker focus that may indicate a decline of interest in reflecting calendric principles in the architecture. Another reason for the departure of the two curves as one approaches the extreme northern zone could be that a number of Late Post-Classic sites included in the latter sample cluster along the east coastal zone of northern Quintana Roo (cf. fig. 3). An obvious orientation factor in this region is the direction of the coast line and it is a fact that a number of sites in this area (e.g., Tulum) simply face the open sea.

A closer look at figure 17 reveals that the points representing alignments that crowd closely upon the zenith passage line, and in a few instances upon the line representing the horizon positions of the sun at solstice (dashed and dotted line), always lie to the left of these lines. Statistically speaking, the observations would appear to anticipate the time of occurrence of these important events in the solar year. Anticipatory observation is a very realistic characteristic of the process of fixing a precise calendar in the landscape, as Zeilik (1985, S1–S24) has demonstrated. Marking the sun at the solstice is particularly difficult because as the target encroaches upon its limiting azimuth, it moves ever more slowly from day to day. That no points lie close and to the right of the zenith sun line in figure 17 may indicate that the counting system especially emphasized the period between the equinox and the zenith passage when the sun moved from the south to the north (setting in the northwest), rather than that between solstice and zenith passage when the sun moved in the opposite direction. We shall return to this detail later.

Following the implications of our general hypothesis further, let us count backward and forward twenty, forty, etc. days from the zenith passage dates and compute a set of orientations to horizon positions that indicate where the sun rose and where it set on those particular dates at various latitudes spanning the peninsula of Yucatan. Then, we can compare the orientations derived from this hypothetical set of calendars to the building alignment data. In Table 3 are the calculations pertaining to hypothetical solar orientation calendars for each of the 1° parallels of latitude from 16°N through 21°N, i.e., roughly from the southern highlands and the Peten to the middle of the northern lowlands. For the dates twenty and forty days before and after each of the two solar zenith passages at each latitude (tabulated horizontally), we list the computed azimuths of sunrise and sunset.

To illustrate how to use this table, consider the entries for latitude 19°N. Zenith passage dates are 20 May (when the sun is moving to the north) and 24 July (when it moves southward). On these days, the sun rises 68°19′ clockwise from true north (or 21°41′N of E) and sets at 291°41′. One uinal prior to these dates corresponds to 30 April and 4 July. On the first of these dates, the sun rises at 74°08′ and sets at 285°52′; on the second, it rises at 65°09′ and sets at 294°50′. If we count twenty days after the zenith passage dates, we arrive at the date pair corresponding to 9 June and 13 August, for which the appropriate tabulated azimuths have been calculated. Note the close inverse symmetry conditions that prevail between this pair of dates and the one corresponding to twenty days before zenith passage. Alignments for pairs of dates forty days before zenith passage also are closely matched by those tabulated for dates occurring forty days after zenith passage.

Several revelations about the environment that confronted the Maya become evident from a careful study of this table. For example, in the southern highland region (16°N latitude), we find that if we mark the setting position of the sun on the zenith passage attained during its northward course, and then if we count backwards from this date two uinals, we arrive almost precisely at the vernal equinox. The sunset point lies close to true west on this date. Moreover, if we count backward two uinals from the second solar zenith passage date, we arrive very nearly at the June solstice, at least as close as one could discern it by fixing an alignment. Counting forward by *two* full uinals from either zenith passage also places us close to the equinoxes and solstices.

Farther to the north, in the Puuc zone for example (about latitude 20°N), we find that while each uinal is separated by the same *time* interval from the zenith passage (the date of this event in the annual cycle having shifted), the solar orientations that are paired with the starting (or ending) of each uinal do not correspond to the equinoctial or solstitial dates.

Other significant data concerning the southern Chiapas highland region may be correlated with the information in Table 3. First, it should be noted that the fiesta of San Lorenzo in Zinacantan, which occurs on 7–11 August, corresponds to a solar zenith passage. Second, the G.M.T. correlation places the beginning of the Long Count at a solar zenith passage appropriate to this latitude. Third, the Tzotzil calendar commences with a solar zenith passage.[2]

Concerning the Tzotzil calendar, Bricker (1982, table 1) has pointed out that the seven *uinals* from 12 April to 31 August cover the period from the months of Yaxkin through Mac when the beginning of the month of Pop is aligned with the winter solstice. It is also at this time that the month names are correctly correlated with the seasons in the Maya area; thus, consulting Table 2, we have:

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[2] We are grateful to V. Bricker for initially attracting our attention to these data as well as for developing the following argument relating the calendars of highland Chiapas to the orientation calendar we proposed earlier for Uxmal, which also is based on twenty-day counts taken from a zenith passage.

*23 March = 0 Xul = Vernal Equinox
12 April = 0 Yaxkin = Magician (Uxmal)
2 May = 0 Mol
22 May = 0 Ch'en = solar zenith passage
1 lunation 11 June = 0 Yax
7 uinals 21 June = 10 Yax = summer solstice
1 lunation 1 July = 0 Zac
21 July = 0 Ceh = solar zenith passage
10 August = 0 Mac
30 August = 0 Kankin = Magician (Uxmal)
*19 September = 0 Muan = Autumnal Equinox

Now, if the Maya New Year corresponded to a solar zenith passage and the month names were aligned with the seasons, then the month of Uayeb would be expected to fall between Mol and Chen or between Zac and Ceh, and not between Cumku and Pop, as is the case in Classic Maya inscriptions. The Tzotzil counterpart of Uayeb does, however, fall between Zac and Ceh, which makes the orientation calendar in Table 2 relevant for highland Chiapas.

While this model appears to work for the Tzotzil *haab,* it does not fit with the Yucatecan *haab.* Of course, it is possible that the Lowland Maya had a separate calendar for calculating events in the solar year, one that began with a solar zenith passage. The case of Tzotzil is interesting because a separate calendar is not required for this purpose. Bricker's comments about the Tzotzil calendar are based on its colonial and modern variants, but if one looks at the Classic version of the calendar, then Uayeb must have fallen between Mol and Chen. This implies that the beginning of the Classic variant corresponds to the solar zenith passage when the sun is on its northerly course and that the beginning of the colonial and modern variants corresponds to the opposing solar zenith passage. Therefore, no matter how one interprets the Tzotzil calendars, they do, indeed, seem to have something to do with solar zenith passage. Finally, Munro Edmonson (personal communication) informs us that the position of Uayeb in the Cakchiquel calendar places New Year's between Zac and Ceh, as is the case with the colonial and modern Tzotzil calendars. Bricker's arguments serve as a springboard for the idea that adaptive calendars developed in one ecological zone of the Yucatan peninsula could have been picked up and perhaps modified somewhat by people from another area. It is realistic to think of calendars as a part of the standard stock of commodities exchanged among cultures during periods of prolonged contact.

Returning to Table 3, a closer inspection of the astronomical data reveals that regardless of latitude, any hypothetical two-uinal marker on the western horizon used to mark the sun on its southerly course would keep the same absolute direction in space even though the direction to sunset at the zenith passage changes (by more than 6° over the range of latitudes spanned by the Maya world). Simply stated, *the sun sets in the same direction all over the Maya world on the days that fall two uinals before this zenith passage.* It is possible that this principle, which follows from the fact that the implied dates occur very close to solstice, may have been recognized by the Maya, though we have no evidence to support such a claim.

We discover that the uinal method of counting the days of the year seems to offer a kind of spatio-temporal harmony unique in the latitudes of southern Mesoamerica, for that method of counting links the solar stations that are obvious empirically and that also were known to be important from the cultural data, namely the equinoxes, solstices, and zenith passages. We do not mean to imply that the ceremonial centers were placed in these latitudes as a result of the discovery of this principle of calendar orientation. In fact, we have little data to support such a claim. Nor do we intend to suggest that the uinal method of counting dates was invented for the purpose of devising an orientation calendar. In our view, a better suggestion would be that at some stage, the Maya realized that orientations could serve as a convenient as well as elegant means of expression of the solar calendar, given their location and their system of counting. Because they were able to determine that the *counting of time and the directions of space go together in this way,* perhaps they were encouraged to develop this particular orientation calendar further.

Operationally, can we apply our hypothetical solar orientation calendar to the alignments of specific Puuc sites? For example, is there a logical place for the 14° mean skew of Puuc sites in such a scheme? Possibly. The implied sunset orientation of 284° azimuth is closely approximated in the table at one uinal before first solar zenith passage on the northward course. Note the entries: 285°52′ at latitude 20°N; 284°24′ at latitude 19°N. But if the observations were made over a slightly elevated horizon, which one indeed might experience in many parts of the Puuc zone, then one would need to reduce each of the tabulated orientations (by 22 minutes of arc for each whole degree of elevation).

We have already proposed that certain outward-looking buildings at Uxmal may have embodied astronomical orientations. The direction of the western facade of the Pyramid of the Magician can be related directly to the solar calendar that we hypothesized. Recall that the 9°N of W orientation of this structure correlates well with sunset two uinals before first zenith passage (9°29′N of W on 12 April). The orientation of the facade of the House of the Old Woman, which embodies the Early Puuc style (but may have been built over), also fits the same hypothetical orientation calendar, as do a number of other structures cited in Table 2. The Palace of the Governor is a special case having nothing to do with the sun in particular, but for which we believe a well-documented argument for astronomical orientation involving another celestial body can be made (namely Venus, via the infra-site orientation to the largest structure at neighboring Nohpat).

There is good evidence from non-astronomical studies that the buildings at Uxmal were laid out consistently and in accordance with a dominant overall plan (in this regard, see G. Andrews 1975, 286–95, and for a different approach to the problem: Hartung 1971, 48–57).

It may be significant that Uxmal, the largest known site in the Puuc zone, also possesses the largest number of outward-looking buildings. Moreover, each faces a vast expanse of open lowland plain and is visible from surrounding sites for many kilometers. Uxmal also appears to have the best consistency between alignment data and an orientation calendar. It is possible that this city was the center from which a regional calendar was controlled and disseminated, or it may have been the place to which the other more inward-looking neighbors turned to borrow fundamental calendrical concepts. In either case, we believe there is enough evidence to suggest that much thinking and experimentation concerning the formalization of the agrarian calendar took place at Uxmal. Thus, building alignments may be regarded as items in the archaeological inventory that provide us with a concrete source of information about an observationally derived solar calendar, a timekeeping device that could reasonably have served as an empirical basis for the more abstract, formal Haab calendar that is mentioned so often in the inscriptions and in the ethnohistoric sources.

A RECAPITULATION: THE ORIENTATION CALENDAR IN A CULTURAL CONTEXT

Modern scientific relativists are not the first individuals in the course of human history who felt compelled to develop formal mechanisms for ordering concepts of space and time. What is revealing about the study of culture is that often we find that people go about fulfilling similar goals in remarkably different ways. In his discussion of the resemblance of the ceremonial center to the indigenous concept of the cosmos, Lathrap (1985, 256) reminds us that "the isolating and dichotomizing tendencies we have learned so well from Descartes and Newton" can lead us to think of certain propositions about the planning of sacred space as "illogical." The evidence offered here and in a number of other works suggests that what seems illogical to us was perfectly normal to the ancient Maya.

The surviving pre-Columbian documents that deal with the calendar suggest to us that in the Mesoamerican mentality the day, the most fundamental time period, possessed an associated spatial direction. The solar orientation calendar is but a concrete extension of the notion of making time more spatial and space more temporal. When we see these concepts united in an elegant and harmonious as well as a practical way—i.e., one that has functional meaning in everyday life—then we are inclined to regard the unifying scheme as a great achievement. We believe that the discovery of a solar orientation principle that associated the uinal method of counting with the significant positions of sun at horizon, discovered very early in the southern highlands, was such an achievement. While we have not been able to trace the orientation calendar in the south owing to a lack of available data, we believe we have detected the product of the transmission and evolution of that calendar in the remains of the Terminal Classic sites of the north, specifically those located in the Puuc region. The hypothetical orientation calendar consisting of twenty-day units pivoted about solar zenith passage offers a satisfactory explanation for the highly directionally focused building alignments we have collected, catalogued, and analyzed here. We can think of no conceivable way of establishing such systematic building orientations over a widespread area without recourse to the use of astronomical bodies. It comes as a surprise to us that, though the idea of deliberate, systematic skewing of Puuc buildings had long been recognized, no detailed working model to house the skew principle has hitherto been proposed. On the other hand, orientation calendars of a nature similar to the one we have developed have been suggested for other areas of Mexico. Thus, Tichy (1974, 1981, 1982) has referred to the possible existence of orientation calendars based on twenty-day time units. He also has proposed that the fundamental angle measuring unit of 4.5° or 1/20 the part of a right angle may have been employed in Mesoamerican architecture, particularly in Central Mexico, an idea that has met some criticism (Aveni 1982).

What do our ideas about Maya orientation calendars contribute to the understanding of various processual models for the development and evolution of Maya culture? If continuity of architectural developments, activity, and site occupation occurred, for example, at Chichen Itza, Mayapan, and Uxmal (the total overlap hypothesis), then we would not be surprised to find similar building alignments that made reference to the same general calendrical scheme. The evidence from the structural alignments argues for the widespread existence of a common orientation calendar that was gradually modified to suit the practical needs of people who inhabited ecological zones across the peninsula which differed markedly from one another. Given these rudimentary results, it would be interesting to refine our study further by collecting and examining more alignment data in the Rio Bec, Chenes, and Peten regions to see whether we can provide one test that might distinguish between total and partial overlap.

It has long been argued that the general flow of goods and ideas that characterize the Classic Maya civilization moved from south to north. In this regard, it is interesting to note that the spatial direction corresponding to the zenith passage-minus-one-uinal position in the calendar count in the Peten possesses very nearly the same orientation as the median skew we find for the Puuc site alignments. This coincidence may reflect a first attempt to establish in North Yucatan a calendric principle inherited from a culture positioned in a southerly environment, a principle that later was to be modified through the layout of buildings that deviated slightly from the main axis of each site in order to suit local celestial, meteorological, but especially agricultural conditions (recall the discussion relating to Table 2). Kurjack and colleagues (1977) have made detailed studies pertaining to the general planning of Puuc ceremonial centers. They have demonstrated that the sites are all scattered more or less evenly over the hill country instead of being clumped in a few places. They rule out defensive features as determinants of site orientation, though they do point to the existence of a wall of fortification around Uxmal. The way the architecture appears spread over the landscape suggests to them that a large number of locally operated institutions administered much of the resources and power available to the society. Thus, they support this "control hypothesis" by noting the existence at each Puuc site of several separate building groups that, except where they are connected by causeways, appear quite isolated and distinct, almost as if to rival one another. (Recall the relative visual perspectives in figures 14 and 15.) They also argue that if a centralized authority were well developed, one would not expect to find three major sites like Uxmal, Kabah, and (the slightly smaller) Nohpat within the small space of fifty-two square kilometers. Still, the fact that causeways (*sacbeob*) connect the sites indicates that these communities must have interacted quite significantly.

No matter what model one might adopt to explain Maya settlement patterns (see Willey 1977 for a summary), the architecturally replicative nature of Maya, and particularly Puuc, centers seems to speak in favor of the existence of some sort of all-pervading ideology (and rules for its practice) that tied people together regardless of how dispersed the social order had become. In the Terminal Classic-Puuc sites, the separateness implied in the "feudal order" (Willey's term) by the development of individual complexes consisting of buildings that look to the center of their own particular grouping is counterbalanced by the overall unity of the site displayed in the careful and deliberate planning and orientation of these complexes about a basic axis. The hierarchical unity proceeds to an even grander scale when we find nearly identical plans and orientations over a range of widely separated sites. We have attempted to demonstrate that the calendar played a role in certain stages of the planning.

Thus, we view the development of calendars as a slow and complex process dependent upon many observations and interpretations, fraught with socio-political and religious considerations. The vagaries of our own Roman-based calendar, about which much better written evidence exists, serve as a vivid reminder that in the matter of timekeeping, time often is not the only consideration. The inscriptions testify that correct timekeeping was a subject about which the Maya were rather particular at nearly all stages of their development and the principle of orienting buildings to reflect a knowledge of the calendar appears to have occupied a major share of their attention.

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TABLE 1. Alignments of Major Maya Structures

Site	Latitude	Longitude	Name of Alignment	Period	Azimuth	Notes & References
Acanceh	20°49′N	89°27′W	Pyramid	LF	188°45′	Marquina (1951, 802–805).
			Stucco Palace	LC	13°17′	Brainerd (1958, 345).
Ake	20°57′N	89°17′W	El Palacio (Str. I)	LC?	188°11′	Pollock (1936, 113–14).
Almuchil	20°08′N	89°52′W	Str. 3	TC	289°33′	Pollock (1980, 406–17). Xculoc outlier.
			Str. 4	TC	19°:	
Altun Ha	17°45′N	88°20′W	B-4	LC	6°56′	Pendergast (1979).
Altun Ha			A-1	LC	10°55′	
Altun Ha			A-5	LC	14°30′	
Altun Ha			A-3	LC	14°52′	
Bakna	19°52′N	90°03′W	SE Court, East Bldg.	EC	288°:	Pollock (1980, 536, fig. 899).
Balche	20°06′N	89°43′W	Group A, Str. 1(?)	EC	218°50′	G. Andrews (n.d., 29–31).
Becan	18°31′N	89°27′W	Str. X	LC	99½°	Potter (1977, 7–61) gives A.D. 605 ± 95, Venus glyph on Str. X-sub.
Cacabxnuc	20°10′N	89°59′W	N Grp.	TC	187°:	Xcalumkin outlier. Pollock (1980, 458–62).
Chacmultun	20°07′N	89°18′W	Main Site Str. A (North Group)	LC-TC	184°20′	Only extant portion. May not accurately reflect alignment of main bldg. Map in Marquina (1951, 739–45). Pollock (1980, 363–66).
Chacmultun			North Grp., Str. B	EC	107°08′	
Chacmultun			Cabal Pak (Cabalpak)	TC	7°16′	
Chacmultun			Xeth-Pool, (Xethpol), So. Str.	TC	289°54′	
Chelemi	20°13′N	90°01′W	Bldg. w. Paintings	TC	132°:	Pollock (1980, 465–70).
Chicanna	18°28′N	89°27′W	Str. I	LC	91½°	Potter (1977, 62–73); Ruppert & Denison (1943, 63–66).
Chicanna			Str. II	LC	281°	Potter (1977, 8) gives A.D. 670 ± 95; 685 ± 95, radiocarbon dates.
Chicanna			Str. XX	LC	181°	A.D. 570 ± 95; 720 ± 95, according to Potter (1977).
Chiapa de Corzo	16°44′	93°01′W	Bldg. 1	LF-EC	205°35′	Not a Maya site.
Chiapa de Corzo			Bldg. 2	LF-EC	206°16′	Not a Maya site.
Chichen Itza	20°40′N	88°34′W	Akab′Dzib	EC	112½°	Looking N. Marquina (1951, pp. 831–900; all buildings).

TABLE 1. (*Continued*)

Site	Latitude	Longitude	Name of Alignment	Period	Azimuth	Notes & References
Chichen Itza			Casa Colorado	LC	282°18′	
Chichen Itza			Retablos	LC	20°18′	
Chichen Itza			Venado	LC	194°29′	Looking N.
Chichen Itza			Phalli	LC	20°22′	Chichen Viejo.
Chichen Itza			Grupo de la Fecha	LC	17°44′	Chichen Viejo.
Chichen Itza			3 Lintels	LC	358°34′	Chichen Viejo.
Chichen Itza			Castillo 2	LC	15°57′	Chichen Viejo.
Chichen Itza			Str. 16	LC	13°19′	Chichen Viejo.
Chichen Itza			Nunnery	LC-TC	11°18′	Bolles (1977).
Chichen Itza			Casa Redonda	TC	284°59′	
Chichen Itza			N. Sacbe	EPC?	5°24′	Looking N.
Chichen Itza			Osario	EPC	18°18′	Axis looking N.
Chichen Itza			Castillo 1	EPC	21°12′	Axis looking N.
Chichen Itza			Warriors	EPC	290°06′	Axis looking N.
Chichen Itza			Caracol (up. plat.)	EPC	292°54′	Aveni, Gibbs, and Hartung (1975).
Chichen Itza			Great Ballcourt	(EPC)LPC	17°24′	Aveni, Gibbs, and Hartung (1975).
Chichen Itza			Jaguars	EPC-LPC	16°06′	Aveni, Gibbs, and Hartung (1975).
Chichen Itza			Tzompantli	LPC	17°36′	Aveni, Gibbs, and Hartung (1975).
Chichen Itza			Venus Platform	LPC	17°18′	Aveni, Gibbs, and Hartung (1975).
Chichen Itza			Mercado	LPC	9°35′	Aveni, Gibbs, and Hartung (1975).
Chinkultic	16°07′N	91°46′W	Principal Structure	LC-TC	240°53′	Ball (1980).
Chuncatzim	20°11′N	89°35′W	Str. 1: Palace Temple	TC	(25°00′)	Pollock (1980, 53–59).
Chunhuhub	20°09′N	89°50′W	Main Palace (West Facade)		285°43′	Pollock (1980, 399–406); Xculoc outlier.
			Adjacent Palace (West Facade)		277°42′	
Chunyaxche (Muyil)	20°06′N	87°30′W	Str. w. Rounded Top	LC?	339°02′	
Coba	20°30′N	87°42′W	Grp. B, Str. I	LC	277°43′	Folan et al. (1983).
Coba			Nohoch Mul (Grp. C)	LC	220°41′	
Comalcalco	18°17′N	93°12′W	North Plaza (N2)	LC	(294°)	G. Andrews et al. (1967).
Copan	14°52′N	89°07′W	Axis of Great Plaza–E Side	LC	354°09′	Morley (1920); Hohmann and Vogrin (1982).

Copan			W Side	LC	353°13′	
Copan			Ballcourt	LC	353°29′	
Copan			Hieroglyphic Stairway	LC	1°15	
Copan			East Court (W Side)	LC	8°42′	
			(N Side, perp.)	LC	8°02′	
Copan			T 16	LC	4°08	
Copan			T 22	LC	7°04′	Closs et al. (1984).
Copan			W Court	LC	5°27′ 9°36′	
Culecab	19°43′N	89°51′W	Only visible structure	LC?	25°20′	
Culuba	21°08′N	87°49′N	Bldg. 1	TC	9°54′	Andrews V (1979, 1–17).
Culuba			Bldg. 2	TC	194°29′	Largest structure.
Dzibilchaltun	21°06′	89°36′W	Temple of Seven Dolls (Str. 1-sub)	LC-TC	273°50′	Stuart et al. (1979).
Dzibilnocac	19°34′	89°36′W	Str. 1	LC	280°56′	Pollock (1970, 25–34); Nelson (1973).
Edzna	19°37′N	90°16′W	5 Story Palace	LC-TC	284°20′	G. Andrews (1975, 246–75); Matheny et al. (1983).
Edzna			Axis Up. Plat. Main Acrop.	LC	286°49′	
Ekbalam	20°53′N	88°07′W	Largest Building	TC?	(2½°)	
El Cedral, Coz.	20°22′N	86°57′W	Str. 1	LPC	289°05′	Sanders (1955, 191). Nearly ⊥ to coast.
El Meco	21°15′N	86°50′N		LPC	93°29′	Sanders (1955, 212–13). Nearly ⊥ to coast.
El Real, Coz.	20°33′N:	86°44′:		LPC	106°27′	Escaloma Ramos (1946, 549–51, 573); Sanders (1955, 194–95).
El Tabasqueño	19°30′N	89°48′W	Rear Wall	LC	4°50′	Pollock (1970, 19–22).
Finca Naranjo, Guat.	14°39′N	90°30′W		?	8°33′	Williamson (1887).
Halal	20°05′N	89°57′W	Acropolis	TC	292°:	Pollock (1980, 546–53).
Haltunchon	20°12′N	90°00′W	Hilltop Grp. West Building	TC	103°:	Xcalumkin outlier. (Pollock 1980, 563–64).
Hochob	19°23′N	89°47′W	Str. 2	LC	197°43′	Pollock (1970, 9–18).
Huntichmul	20°06′N	89°35′W		TC	225°:	Labna outlier. Pollock (1980, 343–46).
Ichmac	20°13′N	89°57′W		TC	113°:	Xcalumkin outlier.
Ikil	20°37′N	88°48′W	Str. 1	(EC?)LC-TC	23°08′	Andrews IV (1968a).
Itzimte	20°00′N	89°44′W	Main grp. 3 Story Bldg.	TC	192½°	Pollock (1980, 554–57); von Euw (1977, 1–31).
			Str. 6	EC	22°	
Izamal	20°57′N	89°01′W	Kinich Kakmoo (up.)	EC-TC(LPC?)	17°11′	Marquina (1951, 805–808); Lincoln (1980, 24–69). Earliest structure is EC, with stairway added in LPC.

TABLE 1. (*Continued*)

Site	Latitude	Longitude	Name of Alignment	Period	Azimuth	Notes & References
Izapa	14°55′	92°11′	Group F Ballcourt	LF	114°29′	Not a Maya site.
Izapa			Bldg. S of Ballcourt	LF	204°42′	Not a Maya site.
Kabah	20°15′N	89°40′W	Codz Pop (2C, Str. 6)	TC	283°36′	Pollock (1980, 140–204).
Kabah			Great Palace (2C, Str. 2)	TC	282°12′	
Kabah			(2C, Str. 3)	TC	16°:	
Kabah			Great Pyramid (1B, Str. 2)	TC	194°:	
Kabah			Arch (1B, Str. 1)	TC	347°12′	Causeway to Uxmal.
Kabah			Los Dinteles (1A, Str. 1)	TC	106°:	
Kabah			Las Grecas (1A, Str. 2)	TC	104°:	
Kabah			(1A, Str. 3)	TC	108°:	
Kabah			(3B, Str. 1)	TC	5°:	
Kabah			(1A, Str. 5)	EC	4°:	
Kabah			(1A, Str. 6)	EC	22°:	
Kabah			Causeway from 1B, Str. 2 to 3B, Str. 1	TC	2°:	
Kaminaljuyu	14°37′N	90°33′W	N Wall of Bath	LF-EC	22°35′	Kidder (1946).
Kiuic	19°58′N	89°30′W	Group 1, Str. 5	TC/EC	102°13′	Pollock (1980, 351–63).
Kiuic			Group 2, Str. 1		282°50′	
Kiuic			Group 3, Str. 2		280°49′	
Kohunlich	18°26′N	88°48′W	Palace of Masks	LC	269°53′	
Kohunlich			Entrada Plaza	LC	190°53′	
Kohunlich			Ballcourt	LC?	284°33′	
Kupaloma	20°33′N	89°56′W		TC	293°:	Oxkintok outlier. Pollock (1980, 327–34).
Labna	20°08′	89°35′W	Mirador	TC	192°02′	Pollock (1980, 7–52).
Labna			Palace Complex	TC/EC	190°–210°:	EC "wing" at 19°.
Labna			Causeway	TC	358°:	
Labna			Arch	TC	130°–310°:	
Mayapan	20°37′N	89°27′W	Castillo (Q-162), N facade	LPC	4°35′	
Mayapan			Temple adorned w. Chac Masks (Q-151)	LPC	192°45′	Pollock et al. (1982).
Mayapan			Round Tower (Q-126)	LPC	192°47′	
Mayapan			Caracol (Q-152)	LPC	282°47′	Aveni and Hartung (1978).

Mixco Viejo, Guat.	14°53′N	90°36′W	Ballcourt	LPC?	191°05′	
Mul-Chic	20°20′N	89°42′W	Bldg. A	EC	295°36′	Pollock (1980, 278).
Muluchtzekel	20°13′N	89°34′W	W Grp.	TC	187°:	Labna-Sayil outlier. Pollock (1980, 81–84).
Nohmul	18°14′	88°36′W	Str. ?	EC:?	17°	
Nohpat	20°19′N	89°42′W	Mound surmounted by bldg. w. vaulted arch	TC	13°14′	Pollock (1980, 276–77).
Nohpat			Great Mound	TC	14°57′	
Oxkintok	20°34′N	89°57′W	Axis No. Grp., Str. 6–So Grp., Str. 2	(LC)-TC	10°16′	Pollock (1980, 281–324). 1B1(EC) at 15°:
Oxkintok			North Group		190½°:	
Oxkintok			North & South Plaza Groups		9–13°:	
Oxkintok			South Group		10½°	3C5 & 6(EC) also at 10½°:
Paalmul	20°35′N:	87°19′W	Str. 1 (Castillo)	LPC	302°52′	Aveni and Hartung (1978); Mason (1927).
Paalmul			Str. 2	LPC	301°54′	Sanders (1955, 204–206).
Palenque	17°30′N	92°02′W	Temple of Inscriptions (lower)	LC	21°55′	Aveni and Hartung (1979).
Palenque			T XIV	LC	117°10′	
Palenque			T S (lower)	LC	119°28′	
Palenque			T C (IV)	LC	211°45′	
Palenque			T F C (V)	LC	312°30′	
Palenque			Ballcourt (axis)	LC	193°29′	
Palenque			X	LC	199°39′	
Palenque			El Conde (VII) (lower)	LC	106°44′	
Palenque			XIII	LC	15°46′	
Palenque			Palace (House D, W face)	LC	287°49′	
Palenque			Group VIII	LC	194°38′	Grouped into two sets of 17° and 23°.
Palenque			Group VIII-2	LC	203°37′	
Palenque			Olvidado	LC	225°	
Pixoy	19°54′N	89°43′W		TC	27°:	Avg. of four structures (±3°); von Euw (1977).
Playa del Carmen	20°36′N	87°18′W	Str. A-1	LPC	27°	Andrews & Andrews (1975).
Poxila	20°49′N	89°49′W	Only standing structure	?	359°	Near Chochola, Yuc. (Hacienda Poxola).
Pta. Islote, Coz.	20°17′N	86°58′W	Temple I	LPC	103°14′	Sanders (1955, 192–94); Freidel and Sabloff (1983).
Puerto Rico	18°35′N	89°24′W	Directions of horizontal shafts in round tower.	LC	27°00′ 22°45′	Andrews IV (1968b). Aveni and Hartung (1978).

TABLE 1. (*Continued*)

Site	Latitude	Longitude	Name of Alignment	Period	Azimuth	Notes & References
Quirigua	15°16′N	89°02′	Temple Plaza: Str. 5	LC	347°28′	Marquina (1951, 600–608); Ashmore and Sharer (1978).
Quirigua			Temple Plaza: Str. 3	LC	351°08′	
Quirigua			Temple Plaza: Str. XIII	LC	350°06′	
Rio Bec	18°20′N	89°22′W	Group B	LC	96°34′	Potter (1977, 94–98); Ruppert and Denison (1943, 29–36).
Sabbache	20°12′N	89°35′W	Court of Str. 1–2	EC	22–25°:	Pollock (1980, 68–80).
Sabbache			Str. 4	TC	25°:	
Sabbache			Str. 5	TC	102°:	
Sabbache			Str. 6	TC	188°:	
San Gervasio, Coz.	20°25′N	86°54′W	Group IV—Str. 34a	LPC	215°22′	Sabloff and Rathje (1975, 88–106); Freidel and Sabloff (1983). Sanders (1955, 198–200); Escalona Ramos (1946).
Santa Rosa Xtampak	19°48′N	89°25′W	Palace	LC	118°29′	Pollock (1970, 46–63).
Sayil	20°11′N	89°40′W	Great Palace (2B1)	TC	192°23′	Pollock (1980, 85–137).
Sayil			Northern Group: (1B2)	EC	4°	
Sayil			Causeway to Group of 3B2	TC	0°:	
Sayil			Group of 3B2		187–193°:	
Sayil			Group of 3C2		191–197°	
Sayil			Group 4B2		192°:	
Sayil			Ballcourt (4B3)		106–286°	
Seibal	16°26′N	89°59′W	Str. 3	LC	276°59′	Willey et al. (1975).
Str. 1 C-5, Coz.	20°32′N	86°45′W		LPC	106°01′	Sabloff and Rathje (1975, fig. 3). Identification not certain. Nearly ⊥ to coast.
Str. C- ?, Coz.	20°33′N	86°44′W		LPC	118°02′	Sabloff and Rathje (1975, fig. 3). Identification not certain. Nearly ⊥ to coast.
Str. C- ?, Coz.	20°31′N:	86°45′W		LPC	116°27′	Sabloff and Rathje (1975, fig. 3). Identification not certain. Nearly ⊥ to coast.
Tancah	20°15′N	87°24′W	Bldg. 12	LPC	19°	Lothrop (1924).
					5°	Sanders (1955, 201–202).

Tikal	17°13′N	89°39′W	Complex P—facade of first pyramid	LC	02°10′		
Tikal			Complex Q—axis	LC	05°28′		C. Jones (n.d.); Carr and Hazard (1961).
Tikal			T I	LC	190°35′		Hartung (1975).
Tikal			T III	LC	98°07′		
Tikal			T IV	LC	11°27′		
Tompul	20°56′N	89°37′W	Only standing structure	TC?	11°10′		Location not certain.
Tonina	17°03′N	92°07′W	Principal Structure	LC	112°03′		Becquelin and Baudez (1979).
					204°13′		
Tulum	20°12′N	87°26′W	Castillo, Str. 1	LPC	291°37′		Lothrop (1924); Marquina (1951, 808–23).
Tulum			Str. 45	LPC	20°44′		Circular structure.
Tulum			T. Frescoes (Str. 18)	LPC	111°48′		
Tulum			Str. 21	LPC	203°40′		
Tzum	19°58′N	89°49′W	Group A	TC	20–28°:		8.5 km W of Bolonchen. NNE-SSW axis. 5 hilltop groups w. hills generally determining location and orientation of buildings. Von Euw (corpus 4-1).
			B		10–20°:		
			C		15–20°:		
			D		12–16°:		
			E		15–20°:		
Uaxactun	17°23′N	89°38′W	E-VIII sub	LF-EC	87°43′		Smith (1950).
							Ricketson (1928).
							Ricketson and Ricketson (1937).
							Aveni and Hartung (n.d.).
Uxmal	20°22′N	89°47′W	Pyramid of the Magician	LC-TC	99°17′		Pollock (1980, 208–75); Foncerrada (1965).
Uxmal			Nunnery—N Bldg.	TC	15°46′	14°48 ± average	Aveni and Hartung (1982b).
			W Bldg.	TC	18°31′		
			S Bldg.	EC	13°20′		
			E Bldg.	TC	11°36′		
Uxmal			Ballcourt	TC	12°30′		
Uxmal			Palace of the Governor	TC	118°05′		Foncerrada (1965); Aveni and Hartung (1982b).
Uxmal			House of the Turtles	TC	109°23′		Hartung and Aveni (1982).
Uxmal			Cemetery Group, W Bldg.	TC	104°		Pollock (1980, 220–29).
Uxmal			North Group	TC	191°:		
Uxmal			North Group to South Group axis	TC	193°:		
Uxmal			Great Pyramid (Str. G)	TC	15°:		
Uxmal			House of the Old Woman	EC	291½°:		Lower Temple.

TABLE 1. (*Continued*)

Site	Latitude	Longitude	Name of Alignment	Period	Azimuth	Notes & References
Uxmal			South Group	TC	12°:	
			Northwest Quadrangle (Str. 1 & 2)	EC	0°:	
Xcalumkin (Holactun)	20°08′N	90°02′W	*Main Group*		188°:	Pollock (1980, 418–56).
			Initial Series Court & Bldg.		17°:	
			S Bldg.		180°:	
			NW Bldg.		176°:	
			Unidentified Structure		12°27′ (192°27′)	
Xcalumkin (Holactun)			*North Hill Group*			
			S Bldg.		240°:	
			N Bldg.		196°:	
			Unidentified Structure		34°12′ (12°42′)	
Xcalumkin (Holactun)			*Hieroglyphic Group*			
			NW Bldg.		107°:	
			Middle Bldg.		7°:	
			S Bldg.		16°:	
			Unidentified Structure		5°34′ (185°34′)	
Xcaret (Pole)	20°37′N	87°05′W	Str. A	LPC	223°59′	Andrews IV, E. W. and A. Andrews (1975).
Xcaret (Pole)			Str. D (round str.)	LPC	52°57′	
Xcaret (Pole)			Str. E II	LPC	53°	
Xcaret (Pole)			Str. E VI	LPC	32°	
Xcoch	20°21′N	89°40′W	Pyramidal mound	TC	295°36′	Pollock (1980, 278); Stephens (1843, V 1: 212–13).
Xcochkax	20°09′N	89°50′W	Southern Building?		206°24′	Pollock (1980, 386–97).
			Northern Building?		99°5′	Pollock (1980, 386–97).
Xcocha	20°03′N	90°07′W	Bldg. of Glyphic Band	TC	207°:	Pollock (1980, 508–15).
Xcucsuc	20°12′N	90°02′W	S Grp.	TC	22°:	Xcalumkin outlier. Pollock (1980, 486–89).
			E Court			
			N Bldg.			
Xcucsuc			S Grp.	TC	287½°:	
			W Court			
			W Bldg.			

Xculoc	20°11'N	89°51'W:	Ballcourt		0°:	Pollock (1980, 377–84).
Xculoc			Portal Vault		12°:	
			Unidentified Structure		9°51'	
Xelha	20°25'N	87°18'W	?	LPC	288°	Sanders (1955, 202–203).
Xkichmool (Xkichmook)	19°53'N	89°32'W	Bldg. 1 (Palace)	LC-TC	288°41'	Pollock (1980, 371–74); G. Andrews (1984, 48–87).
Xkichmool (Xkichmook)			Bldg. 2 ?	LC-TC	285°:	
Xkichmool (Xkichmook)			Bldg. 3 ?	LC-TC	281°01'	
Xlabpak	20°06'N	89°42'W	Str. 1 (Palace)	LC	195°	Pollock (1980, 60–67).
Xpostanil	20°10'N	89°50'	Structure		299°07'	Xculoc outlier.
Xpuhil	18°30'N	89°24'W	Group 1, Str. 1	LC	97°45'	Cf. Same alignment as Str. X at Becan. Potter (1977, 92–94).
Xtampak	20°01'N	90°08'W		TC	207°:	10 km ESE Tenabo, 5 km SW Xcocha. Pollock (1980, 515–18).
Xunantunich	17°07'N	89°07'W	Castillo	LC	351°40'	
Yakalmai	20°13'N	90°03'W	N Grp., West Bldg.	EC	118°:	Xcalumkin outlier. Pollock (1980, 490–94).
Yaxche-Xlabpak	20°03'N:	89°43'W:	Bldg. 3	LC ?	285°52'	Pollock (1980, 346–47). We place the site 14.5 km N and 2 km E of Bolonchen, which disagrees w. Pollock.
Yaxcopoil	20°47'N	89°43'W	Sacbe	TC	344°45 ± 1°	
Yaxcopoil			Principal Str.	TC	4°	
Yaxuná	20°32'N	88°44'W	Unidentified Structure		18°	Brainerd (1958, 337–42).

Explanation of Table 1

Col. 1: Site name listed alphabetically.
Cols. 2 and 3: Site latitude and longitude rounded to the nearest whole minute.
Principal Resources:
Kramer, G. 1940. *Map of Archaeological Sites in the Maya Area.* Tulane: M.A.R.I.
Garza, S. and E. Kurjack 1980. *Atlas Arqueológico del Estado de Yucatan, Mexico.* SEP-INAH.
Inst. Geog. Nac. de Guatemala, 1974. Ministerio de Communicaciones y Obras Publicas.
Col. 4: Name of alignment.
Unless otherwise stated, the facing direction of the building is given. For ballcourts, the axial direction is quoted.

TABLE 1. (*Continued*)

Col. 5: Period.

The following chronology is employed:

LF = Late Formative	300 B.C.	–A.D. 250
EC = Early Classic	250	–A.D. 600
LC = Late Classic	600	–A.D. 800
TC = Terminal Classic	800	–A.D. 1000
EPC = Early Post Classic	1000	–A.D. 1200
LPC = Late Post Classic	1200	–A.D. 1541

(cf. Gendrop 1983).

Col. 6: Azimuth.

In degrees and minutes of arc, measured from north toward east.

Value followed by colon (:) indicates reading was taken at the site with a magnetic compass, then corrected from magnetic to true north (with an error of less than ±1°) or that reading was taken from a map which has been determined to be reliable to ±1° by checking selected readings at or near the site (with transit and astronomical fix).

Azimuths quoted without suffix indicate that they were made at the site with the surveyor's transit and that they are accurate to ±½°.

Col. 7: Remarks and references are self-explanatory.

TABLE 2. Astronomical Alignments Marking the Solar Year at Uxmal

Date	Date		Event	Ideal Orientation	Measured Alignment
	23 Sep		Aut. Equinox	270°30′	Line from Pyramid of Magician*—Plaza of Cem. Grp. (271°55′).
	21 Mar		Vernal Equinox	270°30′	Line from Pyramid of Magician*—Plaza of Cem. Grp. (271°55′).
2 uinals	12 Apr		Solar Zenith Passage minus 2 uinals (40 days)	279°29′	Doorway of Pyramid of Magician* (279°17′).
3 uinals	22 May	1 Lunar Synodic Mo.	Solar Zenith Passage	291°58′	Doorway of House of Old Woman (291½°).
	22 Jun	1 Lunar Synodic Mo.	June Solstice	295°21′	Pyramid of Magician—Center of Patio of Nunnery to Platform of Stelae (296°50′).
2 uinals	22 Jul		Solar Zenith Passage	291°58′	Doorway of House of Old Woman (291½°).
	31 Aug		Solar Zenith Passage plus 2 uinals (40 days)	279°23′	Doorway of Pyramid of Magician (279°17′).
Special Event Every 8 Yrs:			Rise Venus Max. So.	118°03′	Doorway Governor's Palace 118°05′, 118°11′ (2 msmts.)
			Set Venus Max. So.	241°15′	Pyramid of Magician to W. Grp. (240°20′).

* In each case the sight-line is taken from the Chenes Temple of the Pyramid of the Magician.

TABLE 3. Hypothetical Solar Orientation Calendars Centered about Zenith Passage Dates
(Read Azimuth of Orientation & Date for Each Entry)

Time of Year Latitude		Z.P.	−40 Days	Z.P.	−20 Days	Z.P.		Z.P.	+20 Days	Z.P.	+40 Days
Northern Lowlands	21°N	79°03′	16 Apr	72°06′	6 May	67°04′	26 May	64°35′	15 Jun	65°03′	5 Jul
		65°01′	9 Jun	64°36′	29 Jun		19 Jul	72°08′	8 Aug	79°01′	28 Aug
		280°56′	16 Apr	287°53′	6 May	292°56′	26 May	295°24′	15 Jun	294°56′	5 Jul
		294°58′	9 Jun	295°23′	29 Jun		19 Jul	287°51′	8 Aug	280°59′	28 Aug
Puuc	20°N	81°28′	10 Apr	74°08′	30 Apr	68°19′	20 May	65°12′	9 Jun	64°55′	1 Jul
		64°50′	14 Jun	65°09′	4 Jul		24 Jul	73°50′	13 Aug	81°01′	2 Sep
		278°32′	10 Apr	285°52′	30 Apr	291°41′	20 May	294°47′	9 Jun	295°04′	1 Jul
		295°10′	14 Jun	294°50′	4 Jul		24 Jul	286°09′	13 Aug	278°58′	2 Sep
	19°N	83°07′	6 Apr	75°35′	26 Apr	69°32′	16 May	65°49′	5 Jun	64°50′	25 Jun
		64°51′	18 Jun	65°44′	8 Jul		28 Jul	75°16′	17 Aug	82°39′	6 Sep
		276°52′	6 Apr	284°24′	26 Apr	290°27′	16 May	294°11′	5 Jun	295°10′	25 Jun
Rio Bec–Chenes		295°08′	18 Jun	294°15′	8 Jul		28 Jul	284°43′	17 Aug	277°21′	6 Sep
	18°N	84°46′	2 Apr	77°05′	22 Apr	70°44′	12 May	66°31′	1 Jun	64°44′	21 Jun
		64°45′	22 Jun	66°26′	12 Jul		1 Aug	76°45′	21 Aug	84°17′	10 Sep
		275°13′	2 Apr	282°55′	22 Apr	289°15′	12 May	293°28′	1 Jun	295°16′	21 Jun
		295°15′	22 Jun	293°33′	12 Jul		1 Aug	283°15′	21 Aug	275°42′	10 Sep

Peten	17°N	86°26′	29 Mar	78°37′	18 Apr	71°55′	8 May	67°19′	28 May	65°12′	17 Jun
		65°11′	26 Jun	67°12′	16 Jul		5 Aug	78°15′	25 Aug	85°56′	14 Sep
		273°33′	29 Mar	281°22′	18 Apr	288°04′	8 May	292°40′	28 May	294°47′	17 Jun
		294°48′	26 Jun	292°47′	16 Jul		5 Aug	281°44′	25 Aug	274°04′	14 Sep
Southern Highlands	16°N	87°42′	26 Mar	79°48′	15 Apr	73°04′	5 May	67°52′	25 May	65°30′	14 Jun
		65°31′	30 Jun	68°04′	20 Jul		9 Aug	79°47′	29 Aug	87°34′	18 Sep
		272°17′	26 Mar	280°11′	15 Apr	286°55′	5 May	292°07′	25 May	294°30′	14 Jun
		294°29′	30 Jun	291°55′	20 Jul		9 Aug	280°12′	29 Aug	272°26′	18 Sep

Notes to Table: Entries give azimuth measured from the north. All calculations were performed for first/last gleam of sun at horizon of elevation 0° using the computer program tabulated in Aveni (1980, 125–128). We have employed solar declinations for the mid-years between leap years tabulated in the *American Ephemeris and Nautical Almanac* (Wash.: U.S. Supt. of Documents).

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